TSL Law Group
8096 N. 85TH WAY, SUITE 105
SCOTTSDALE, ARIZONA 85258
WORK: (602) 803-8811
WWW.TSLLAWGROUP.COM

February 10, 2020

Via hand-delivery and email to: sscantlebury@azwater.gov

Sharon Scantlebury
Docket Supervisor
Arizona Department of Water Resources
P.O. Box 36020
Phoenix, Arizona 85006-6020

Re: Comments on Turf Requirements in the Proposed Fourth Management Plan for the Phoenix Active Management Area

Dear Ms. Scantlebury,

The Paradise Valley Country Club ("PVCC") appreciates the opportunity to submit formal written comments on the Proposed Management Plan for the Phoenix Active Management Area for the Fourth Management Period, 2010-2020 (January 3, 2020) (the "Proposed Plan"). PVCC is committed to being part of the solution to Arizona's water management challenges and is encouraged that the Arizona Department of Water Resources ("ADWR") is willing to consider its comments on the Proposed Plan. PVCC understands the importance of attaining the management goal of the Phoenix Active Management Area ("AMA"), "safe-yield" by 2025, in an effort to "achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area." A.R.S. § 45-561(12).

- *The golf industry uses very little groundwater compared with its substantial contribution to the Arizona economy.*

Although golf water use accounted for only 3% of Arizona's groundwater use and 1.1% of Arizona's surface water use, the Arizona golf industry had a total economic contribution of approximately $3.9 billion in sales, including golf facility operations, golf tourism, and golf-related business in 2014. Duval D., Kerna A., Frisvold G., Umeda K. and Li R., Executive Summary, *Contribution of the Golf Industry to the Arizona Economy in 2014* (December 2016) at 1-3. Including direct and multiplier effects, a total of more than 41,700 jobs and $1.5 billion in labor income were supported by the Arizona golf industry, and an estimated $72 million in state and local taxes were directly supported by golf facility operations in 2014. *Id.* Residential real estate premiums associated with all homes ever built in golf course communities in Arizona was estimated to be nearly $2.1 billion. *Id.*

- *The golf industry is committed to water conservation and sustainable management practices.*

The golf industry as a whole supports water conservation and sustainable management practices, demonstrated by the fact that they have been early adopters of new technologies promoting water and energy efficiency. Although golf water use represented only 3.5% of total AMA water use, renewable water supplies represented 52% of AMA golf water use, and effluent use increased by 27% between 2004 and 2014. *Id.* at 3. In addition, based on a 2016 survey, golf facilities reported an average annual water savings of 19.5% due to adjustments made as a result of irrigation audits. *Id.* at 4. Golf facilities also reported removing an average of 10.4 acres of turf grass and reducing over-seeded acres from 89.3 acres to 75.8 acres between 2009 and 2014. *Id.* Furthermore, 39% of responding golf facilities have a partnership with a conservation organization. *Id.*

- *PVCC is committed to water conservation and sustainable management practices.*

PVCC golf course was originally constructed in 1953, so the course was grandfathered in under the Groundwater Code as a pre-1985 course. PVCC is an Individual User and relies on water delivered by EPCOR - Paradise Valley,[1] a Municipal Water Provider, for its water supply. From its inception, PVCC has been committed to water conservation and has been an early adopter of new conservation technologies. Since 2006, PVCC has invested over $3.2 million in golf course renovations, reducing turf acres, replacing turf with low water use plants and implementing new technologies to reduce water use and improve water efficiency. In addition, PVCC has integrated water conservation into its daily operations and course management by employing three degreed agronomists and two full-time irrigation technicians on staff, and by utilizing a dedicated pump station to maintain accurate pressure and sprinkler performance, an onsite weather station for evapotranspiration-based irrigation scheduling, and handheld moisture meters to verify watering needs.

- *Conservation requirements for industrial users must be scientifically sound and economically reasonable.*

PVCC recognizes that for the First, Second and Third Management Plans, ADWR was required to include "mandatory conservation programs for all persons withdrawing, distributing or receiving groundwater *designed to achieve reductions in withdrawals of groundwater*." A.R.S. § 45-563(A) (emphasis added). In addition, for industrial users, these programs had to "establish conservation requirements based on the use of the latest commercially available conservation technology *consistent with reasonable economic return*." A.R.S. § 45-566(A)(2) (emphasis added). Therefore, ADWR was required to evaluate whether its proposed conservation requirements for Industrial Users in the First, Second and Third Management Plans were 1) scientifically sound measures to reduce groundwater withdrawals and 2) reasonable from an economic standpoint.

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[1] As a Municipal Water Provider EPCOR – Paradise Valley must comply with conservation requirements under the Proposed Plan. As an Individual User, PVCC's responsibility for compliance with Industrial User conservation requirements is governed by Section 5-610, Individual User Requirements for Municipal Providers and Individual Users, *Proposed Plan* at Municipal 5-35 to 37.

- *The conservation requirements adopted in the First, Second and Third Management Plans for golf courses are not scientifically sound.*

The conservation requirements adopted for golf courses in the first three management plans were based on an evaluation of the consumptive use of bermuda grass at a 75% efficiency rate.[2] The application rates arrived at using these assumptions did not accurately reflect golf course water needs using the latest commercially available conservation technology consistent with reasonable economic return. Golf courses typically use bermuda grass in the summer, but the standard practice of the industry is to over-seed with rye grasses in the winter, which requires more water to achieve optimal playability and remain competitive. In addition, if golf courses apply too little water, they can develop salinity problems due to inadequate leaching. Also, the consumptive use of turfgrass does not necessarily equal the amount of water needed at the delivery point.

In fact, the University of Arizona Cooperative Extension program analyzed ADWR's water duties for large turf facilities and found that ADWR regulations are "too stringent and provide insufficient water to: 1) produce acceptable quality turfgrass and 2) sustain leaching requirements necessary to avoid problems with salinity." Brown, Dr. Paul, *Evaluation of ADWR Water Duties for Large Turf Facilities*, University of Arizona Cooperative Extension AZ 1381 (June 2006) at I. The study concluded that "the water duties will prove inadequate for nearly all Tucson and Phoenix LTFs [large turf facilities] in dry years" and "the adequacy of the water duties in normal years appears to be 'facility dependent' in both locations." In other words, "[f]acilities with less efficient irrigation systems and/or soil with poor infiltration characteristics would likely find the duties inadequate in normal years." *Id.* at 13.

Therefore, the conservation requirements adopted for golf courses in the First, Second, and Third Management Plans were unattainable because they were not scientifically sound. However, ADWR created Allotment Additions, the Treated Effluent Use Adjustment, and the Reduction of Turfed Acreage Incentive which helped the golf industry comply with Maximum Annual Water Allotments. Although many golf courses have been able to comply with their Maximum Annual Water Allotments because of these additions, adjustments, and incentives, the underlying water duties were nevertheless based on unattainable application rates that were not founded upon sound science.

- *Additional conservation requirements for industrial users in the Fourth Management Plan are discretionary and must be feasible.*

In the Fourth Management Plan for the Phoenix AMA, ADWR has the discretion to determine whether or not to include, "*if feasible*, additional conservation requirements for non-irrigation uses and intermediate conservation requirements."[3] A.R.S. § 45-567(A)(2) (emphasis added). The fact

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[2] This statement is based on ADWR staff responses to questions at the Management Plan Work Group Industrial Subgroup Turf Breakout Meeting on October 24, 2019.

[3] The Municipal Conservation Program Description in the Proposed Plan states that, "the director is required to establish "additional conservation requirements for non-irrigation uses…"

that the Arizona Legislature made the conservation programs in the first three management periods mandatory but made additional conservation requirements for non-irrigation uses in the fourth management period discretionary can only be interpreted to mean that they understood it might not be feasible to introduce new mandatory reductions. Therefore, ADWR must consider the *feasibility* of any additional conservation measure it proposes for non-irrigation uses in the Fourth Management Plan, and it has the discretion to continue the conservation program from the Third Management Plan with no changes as it did in the Tucson and Prescott AMAs.[4] Indeed, implementing additional conservation measures in the Fourth Management Plan for the Phoenix AMA that were not implemented in the Fourth Management Plans for the Tucson and Prescott AMAs will put golf courses in the Phoenix AMA at a competitive disadvantage because their allotments will be reduced while allotments in the Tucson and Prescott AMAs will stay the same.

- *ADWR should not adopt the proposed additional conservation requirements for golf courses in the Proposed Plan because the requirements are not feasible.*

ADWR has not determined whether its proposed additional conservation requirements in the Proposed Plan are feasible. According to ADWR staff, a review was done using ADWR's database to determine if golf courses could comply with the proposed additional conservation measures in the Proposed Plan.[5] However, ADWR's data is out of date and in some cases inaccurate. Compliance with the Maximum Annual Water Allotment has largely been achieved because of Allotment Additions, the Treated Effluent Use Adjustment, and the Reduction of Turfed Acreage Incentive.

Application Rate: The proposed reduction in the application rate for "planted acres" from 4.9 to 4.75 acre-feet per acre at five acres per hole in the Proposed Plan is not based on sound science and is not economically feasible for many golf courses. *See* Section 6-704, Calculation of Planted Acres Application Rate for Golf Courses, *Proposed Plan* at Industrial 6-33. Scientific research shows that the application rates in the Third Management Plan were unattainable for golf courses in the Phoenix and Tucson AMAs, except in wet years when increased precipitation provides additional water supplies. *See supra Evaluation of ADWR Water Duties for Large Turf Facilities.* Therefore, an additional reduction in the application rate is unattainable and not feasible. Indeed, adopting a more restrictive application rate in the Fourth Management Plan for the Phoenix AMA

(A.R.S. § 45-567(A)(2)." Section 5.3.8.1, Individual User Requirements, *Proposed Plan* at Municipal 5-15 (emphasis added). This quote is misleading because it does not include the "if feasible" language, suggesting that ADWR's responsibility is mandatory instead of discretionary.

[4] The Municipal Conservation Program Description in the Proposed Plan also states that, aside from the prohibition on turf-related facilities larger than 90 acres, "[a]ll other individual user requirements are not modified and *ADWR has not included any additional conservation requirements for individual users from those included in the 3MP.*" Section 5.3.8.1, Individual User Requirements, *Proposed Plan* at Municipal 5-15 (emphasis added). This appears to be in conflict with Section 5-610, which requires that Individual Users must comply with Section 6.7 and the reduced application rates for turf-related facilities.

[5] This statement is based on ADWR staff responses to questions at the Management Plan Work Group Industrial Subgroup Turf Breakout Meeting on October 24, 2019.

but not in the Fourth Management Plans for the Tucson and Prescott AMAs will put golf courses in the Phoenix AMA at a competitive disadvantage because their allotments will be reduced while allotments in the Tucson and Prescott AMAs will stay the same.

Recommendation 1: ADWR should not reduce the application rate for golf courses in the Phoenix AMA during the Fourth Management Period.

Allotment Addition for Over-Seeding: The Proposed Plan includes Allotment Additions for newly turfed area establishment, revegetation, body of water fill and refill, leaching of saline water supplies, and for contiguous facilities. Section 6-707, Allotment Additions, *Proposed Plan* at Industrial 6-37 to 38. Because the Application Rates for golf courses in the Proposed Plan do not account for over-seeding, which is a standard practice for golf courses in the Phoenix AMA, ADWR should include an Allotment Addition for Over-Seeding in the Fourth Management Plan.

Recommendation 2: Because over-seeding is not accounted for in the Application Rates for golf courses, ADWR should consider creating an Allotment Addition for Over-Seeding in the Fourth Management Plan.

Flexibility Account: The Proposed Plan provides that "a flexibility account shall be established for a turf-related facility with a beginning balance of zero acre-feet." Section 6-708(B)(1), Compliance with Maximum Annual Water Allotment, *Proposed Plan* at Industrial 6-38 to 40. To promote greater resiliency for golf courses, ADWR should carry over flexibility account balances from the third to the fourth management periods, giving golf course managers more time to comply with reductions in their Maximum Annual Water Allotments.

Recommendation 3: To allow more time to comply with reductions in Maximum Annual Water Allotments, ADWR should carry over Flexibility Account balances from the third to the fourth management periods.

90-Acre Turfed Acreage Cap: The Proposed Plan provides that "[b]eginning with 4MP, turf related facilities are limited to a maximum of 90 acres of water-intensive landscaped area."[6] *See* Section 6.1.2.2, Turf-related Facilities, *Proposed Plan* at Industrial 6-2. ADWR has not determined if this proposed additional conservation requirement is feasible for pre-1985 golf courses. While it may be reasonable from an economic standpoint to construct a new golf course with 90 acres of turf, it may not be economically feasible for existing golf courses with over 90 acres of turf to comply with this turfed acreage cap. The high cost to remove turf and replace it with low water use plants along with the rising cost of water in the Phoenix AMA could put some courses out of business. Also, applying the 90-acre turfed acreage cap to pre-1985 golf courses in the Fourth Management Plan for the Phoenix AMA but not to pre-1985 golf courses in the Tucson and Prescott AMAs puts Phoenix AMA courses at a competitive disadvantage by reducing their allotments while leaving Tucson and Prescott AMA allotments unchanged from the Third Management Plan.

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[6] This prohibition also applies to Individual Users: "ADWR has instituted a prohibition on turf-related facilities larger than 90 acres for the 4MP." Section 5.3.8.1, Individual User Requirements, *Proposed Plan* at Municipal 5-15 (emphasis added).

The amount of groundwater that will be saved by this proposed regulation is minimal in comparison with the substantial costs that will be incurred by the impacted golf courses. However, if ADWR decides to impose "a prohibition on turf-related facilities larger than 90-acres" in the Fourth Management Plan, it should consider phasing in a reduction to the application rate for historic acres over time so that existing golf courses can adjust to the allotment reductions gradually.

Recommendation 4: ADWR should not impose a prohibition on turf-related facilities larger than 90-acres in the Fourth Management Plan for the Phoenix AMA. However, if ADWR imposes a cap on turfed acreage, it should consider gradually phasing in a reduction to the application rate for historic turf acres over time.

Reduction of Turfed Acreage Incentive: In the Third Management Plan for the Phoenix AMA, ADWR included an "incentive to reduce water-intensive landscaped area." Section 6.3.4.1.2.1, Reduction of Turfed Acreage, *Third Management Plan for Phoenix Active Management Area* at 6-30. The incentive provided:

> For pre-1985 and post-1984 golf courses, the maximum annual allotment is based on the maximum area of turf and bodies of water developed at each facility from 1980 through 1984 and from 1985 through 1989, respectively. Thus, *removal of acreage planted from 1980 to 1984 for a pre-1985 golf course and from 1985 to 1989 for a post-1984 golf course will not decrease the facility's allotment. Id.* (emphasis added)

Eliminating the Reduction of Turfed Acreage Incentive in the Proposed Plan punishes those courses who took advantage of the incentive. PVCC detrimentally relied on the Reduction of Turfed Acreage Incentive in the Third Management Plan for the Phoenix AMA, which took effect on January 1, 2002, and invested over $3.2 million in golf course renovations to remove turfed acreage, replace it with low water use plants, and to install highly efficient irrigation systems. When PVCC made the decision to spend millions of dollars on water conservation measures, its investment backed expectation was that removal of historic acreage would not decrease its allotment. The discontinuation of the Reduction of Turfed Acreage Incentive in the Proposed Plan in favor of an immediate cut in the allotments of pre-1985 golf courses who responded to the incentive by investing in water conservation is not feasible. ADWR should continue this incentive in the Fourth Management Plan.

Recommendation 5: ADWR should continue the Reduction of Turfed Acreage Incentive in the Fourth Management Plan by including total historic turf acres when calculating Maximum Annual Water Allotments for pre-1985 golf courses.

Water Management Assistance Grants: If ADWR imposes a cap on turfed acreage in the Fourth Management Plan, it should prioritize Water Management Assistance Grants for large turf facilities to remove turfed acreage. *See* Section 9.5.1, Needs Identified in the 4MP, *Proposed Plan* at Water Management Assistance 9-4.

Recommendation 6: ADWR should prioritize Water Management Assistance Grants for large turf facilities to remove turfed acreage.

- *ADWR has the discretion to implement an alternative conservation program for industrial users.*

ADWR has the discretion to implement an alternative conservation program for Industrial Users and has not done so. Since the Second Management Plan, ADWR has implemented alternative conservation programs for municipal users and since the Third Management Plan, ADWR has implemented alternative conservation programs for agricultural users. Looking forward, it would be beneficial for ADWR to consider an alternative conservation program for Industrial Users in the Fifth Management Plan that will most effectively achieve the goal of safe yield by 2025. Like similar programs for agricultural and municipal users, an industrial user program could be based on best management practices and include additional incentives to reduce turfed acreage and to use renewable water supplies.

Recommendation 7: ADWR should consider developing an alternative conservation program for Industrial Users that is scientifically sound, reasonable from an economic standpoint, and feasible.

In conclusion, PVCC hopes to continue collaborating with ADWR to share information and expertise and to determine the optimal strategy to promote water conservation and efficiency within the golf industry. PVCC appreciates this opportunity to provide comments on the Proposed Plan and ADWR's willingness to take these comments into consideration prior to adopting the Fourth Management Plan for the Phoenix AMA. PVCC reserves the right to comment on any future proposed management plans for the Phoenix AMA and intends to continue its participation in Management Plan Work Group discussions for the Fifth Management Plan.

Please don't hesitate to contact me should you have any questions. We welcome the opportunity to further discuss our comments with ADWR staff.

Sincerely,

Alexandra M. Arboleda
Counsel for Paradise Valley Country Club

Enc: Evaluation of ADWR Water Duties for Large Turf Facilities
Contribution of the Golf Industry to the Arizona Economy in 2014

cc: Thomas Buschatzke, ADWR Director
Natalie Mast, Management Plans Program Manager
Einav Henenson, AMA Director
Steve Richardson, Paradise Valley Country Club General Manager
Rob Collins, Paradise Valley Country Club Golf Course Superintendent

ARIZONA COOPERATIVE EXTENSION
THE UNIVERSITY OF ARIZONA.
College of Agriculture and Life Sciences
AZ1381
06/06

EVALUATION OF ADWR WATER DUTIES FOR LARGE TURF FACILITIES

Introduction

The Arizona Department of Water Resources (ADWR) limits the amount of groundwater large turf facilities (LTFs; ≥10 acres of turf) may use for irrigation in the Tucson and Phoenix Active Management Area (AMAs). Current ADWR regulations effectively cap groundwater use at 4.6 and 4.9 acre-feet per acre per year (af/a/yr) for turfgrass grown within the Tucson and Phoenix AMAs, respectively. Operators of LTFs have expressed concerns that ADWR regulations (water duties) are too stringent and provide insufficient water to: 1) produce acceptable quality turfgrass and 2) sustain leaching requirements necessary to avoid problems with salinity. University of Arizona research appears to support the concerns of LTFs. Brown et al. (2001) conducted a three-year study to develop crop coefficients (Kcs) for the typical desert turf system consisting of bermudagrass in summer and overseeded ryegrass in winter. Crop coefficients are adjustment factors that when used in conjunction with weather-based estimates of reference evapotranspiration (ETo) provide accurate estimates of turf water use (ETt). When the Kcs developed by Brown et al. were applied to long term averages of ETo available from the Arizona Meteorological Network (AZMET), annual ETt was projected to approach 4.9 af/a/yr in both the Tucson and Phoenix AMAs, indicating annual evaporative demand equals (Phoenix) or exceeds (Tucson) the water duties in the two AMAs. If these projections prove to be true, operators of LTFs would have to rely on precipitation (P) to offset soil water deficits resulting from the duties and facilitate deep percolation required to remove (leach) salts from the turf root zone.

In an effort to help clarify this issue, a study was initiated on the large weighing lysimeters located at the University of Arizona Karsten Turf Research Facility in Tucson. The objective of the three-year study was to determine if the ADWR turf water duty for the Tucson AMA provided sufficient water to: 1) sustain acceptable quality turfgrass and 2) support acceptable levels of leaching when turfgrass was irrigated using the Kcs recommended by Brown et al. This report first summarizes the results of this Tucson study, then concludes with a discussion of how to translate the study results to LTFs in both the Tucson and Phoenix AMAs.

Materials & Methods

The study was conducted between 1 October 1997 and 30 September 2000 at the University of Arizona Karsten Desert Turf Research Facility located in Tucson, AZ. Two large weighing lysimeters, centrally located within a 5 acre (2.2 ha) field research area, were used to monitor the water balance of a desert turf system, consisting of 'Tifway' bermudagrass in summer and overseeded 'Froghair' intermediate ryegrass in winter. The lysimeters are cylindrical in shape with diameter and depth equal to 8.2′ (2.5 m) and 13.2′ (4 m), respectively. The lysimeter soil is uniform with depth and is classified as a Vinton fine sand.

Each lysimeter rests on a modified truck scale which is connected to a load cell. An automated data logger is used to monitor the output signals from the load cells. The data logger is programmed to sample load cell outputs every 2 seconds and compute 10-minute averages of lysimeter mass. Scale accuracy is about +/- 0.66 lb (300 g) which is equivalent to a depth of 0.0024″ (0.06 mm) of water. Water draining to the bottom of the lysimeters is removed using a vacuum pump that is attached to a series of suction candles. Drainage water is stored in onboard tanks until removed and quantified by lysimeter technicians.

A dual irrigation system serves the lysimeter area, allowing the use of tertiary effluent or potable groundwater for irrigation. One lysimeter was irrigated with effluent while the other was irrigated with groundwater. The quality of the two water sources differed in two important categories: electrical conductivity (0.4 dS/m for groundwater and 1.0 dS/m for effluent) and total nitrogen (N; 3 mg N per liter for groundwater and 13 mg N per liter for effluent). Irrigation was supplied to each lysimeter using low trajectory Rain Bird 1804 Series pop-up sprinkler heads with head spacing set at 12′ [3.45 m (square spacing)]. The precipitation rate of the sprinkler system averaged 2.09″/hr (53 mm/hr) and irrigation non-uniformity averaged 0.93 using Christiansen's Coefficient of Uniformity (CU; Christiansen, 1942). Irrigation was regulated using a Rain Bird Maxi-5 irrigation control system and its attendant weather station. The Maxi-5 weather station generates estimates of ETo which must be multiplied by 0.90 to make them equivalent to ETo as computed by the Arizona Meteorological Network (ETo a). Irrigation was applied

daily in the predawn hours with amount set equal to 72% of EToa in winter (Nov-May) and 77% of EToa in summer (Jun-Oct). A different irrigation regime was implemented during the period of overseed establishment which occurred during the latter half of October in each year. During this two-week establishment period, light irrigations were applied 5-7 times per day to maintain a moist surface and encourage rapid and uniform germination. The irrigation rate during the period of overseed establishment period averaged ~0.20"/dy (5.08 mm/dy) which was ~102% of EToa.

During periods of rainfall, irrigation amount was determined by subtracting rainfall from EToa during the previous 24-hr period. Irrigations were eliminated on days when rainfall exceeded EToa. Rainfall amounts in excess of EToa were assumed stored in the soil and used to offset future evaporative demand with the proviso that stored rainwater could never exceed 0.5" (12.7 mm). Irrigation was resumed once this stored supply of rainwater was depleted.

The turf received N at a rate of approximately 31 lb/a/month (35 kg/ha/month) from irrigation water and chemical fertilizer (NH_4SO_4 in liquid form). Monthly applications of fertilizer N were adjusted based on the irrigation rate and N concentration in the irrigation water. Potassium (K) and phosphorus (P) were applied every six weeks at rates of 21.6 and 14.4 lb/a (24 and 16 kg/ha), respectively. Granular K_2SO_4 (0-0-52) and $Ca(H_2PO_4)_2$ (0-20-0) served as fertilizer sources for K and P, respectively. The turf was mowed two to three times per week during the summer and one to two times per week during the winter with a reel mower. Mowing height was set at 0.875" (22 mm) in summer and 1.0" (25 mm) in winter.

Turf evapotranspiration (ETt) was determined daily in units of mm/d for the 24-hr period ending at midnight using the soil water balance equation:

$$ETt = I + P - S - D \quad (1)$$

where I is the amount of irrigation, P is precipitation, S is the daily change in soil moisture storage and D is the amount of drainage. Irrigation was applied on most days during a 15-minute period before sunrise. The gain in lysimeter mass during this period was set equal to the amount of irrigation (evaporation assumed negligible). Precipitation was measured in two ways: 1) from the increase in lysimeter mass during precipitation events, and 2) using a tipping bucket rain gauge. The greater of the two precipitation measurements was set equal to P. The change in lysimeter mass for the day was assumed equal to S, and D was obtained by multiplying the volume of drainage water in liters (L) by a specific gravity of 1.0 kg/L.

Tifway bermudagrass, established on the lysimeters and the surrounding 10000 ft^2 (0.09 ha) area by sprigging during the summer of 1994, served as the turf surface during the summers of 1998,1999 and 2000. Froghair intermediate ryegrass was overseeded into the bermudagrass at a rate of 600 lb/a (670 kg/ha) on a pure live seed basis in mid-October of each year and served as the turf surface during the winter. Dates of overseeding were 13,15 and 13 October of 1997, 1998 and 1999, respectively.

Results & Discussion

The lysimeter facility allows one to accurately quantify the water balance of the standard desert turf system consisting of bermudagrass in summer and overseeded ryegrass in winter. Components of the water balance include precipitation and irrigation as inputs, and evapotranspiration (ETt) and deep percolation (drainage) as losses (Fig. 1). The difference between inputs and losses represents the change in soil moisture storage over the course of the year. For this study, a "turf year" begins on 1 Oct and concludes on 30 Sep of the following year. The abbreviations TY98, TY99, and TY00 are used to designate the periods 1 Oct 1997 - 30 Sep 1998, 1 Oct 1998 - 30 Sep 1999, and 1 Oct 1999 - 30 Sep 2000, respectively. Tables 1-3 provide a numerical summary of the water balance components by year while Figures 2-4 present these same results in a graphical format. Average values of the water balance components over the course of the study (3 years) are provided in Table 4 and Figure 5. The tables provide the components for the individual lysimeters as well as average values of each component (mean from both lysimeters). The figures simply present the average values for each component.

Turf Performance

Turf performance over the period of study was rated as acceptable or higher with the exception of some finite periods of weaker turf performance associated with spring and fall transition. Early June proved to be the period where poor turf performance was observed in the spring. Spring transition is often delayed at the study location due to cool night temperatures. Poorer turf performance was also evident in late October and early November during the period of overseed establishment. Given that turf performance is commonly inferior during these spring and fall transition periods, it was concluded that the irrigation regime utilized in this study did not negatively impact turf performance.

Turf Evapotranspiration

Turf ET varied from 56.2" (1428 mm) in TY98 to 62.4" (1584.4 mm) in TY00 and averaged 59.2"/yr (1504 mm/yr) over the period of study. The ETt values recorded from the two lysimeters were remarkably consistent and varied by less than 2"/yr (50.8 mm) over the course of the study (see Tables 1-3). Turf ET exceeded the Tucson water duty (55.2"/yr or 1402 mm) in each year of the study, providing clear evidence that the quantity of water available from the Tucson duty is insufficient in most years to fully offset evaporative demand. Over the course of this study, ETt exceeded the water duty by an average of 4.0"/yr (101.6 mm) which represents the average water deficit that must be made up from precipitation. Table 5 provides ETt, ETo and the ratio of ETt to ETo for each year of the study.

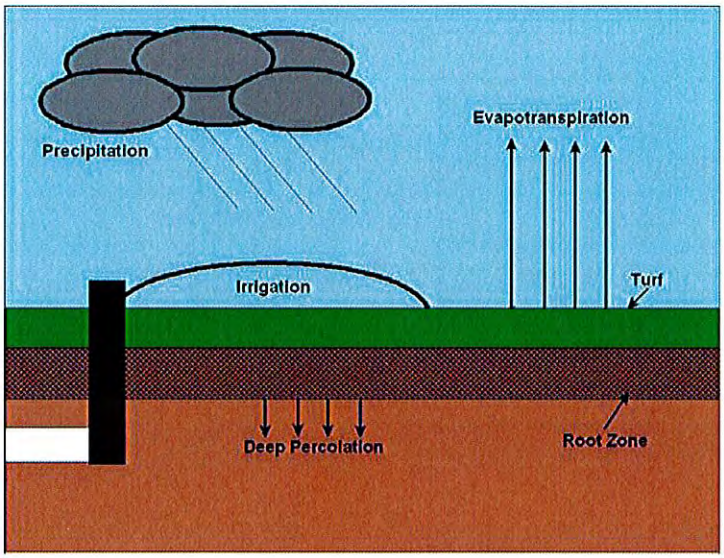

Figure 1. Graphical depiction of the soil water balance for a turf system. Precipitation and irrigation serve as inputs of water into the system. Water is lost from the system through deep percolation and turf evapotranspiration.

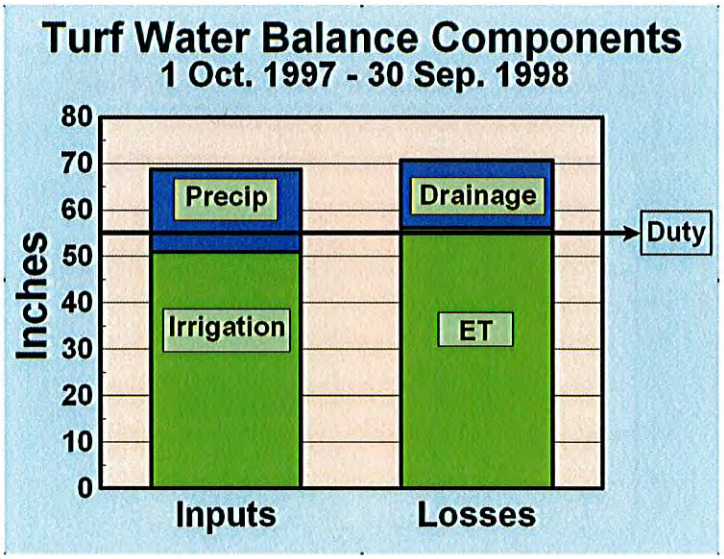

Figure 2. Components of the soil water balance for TY98. The arrow indicates the quantity of water provided in ADWR's water duty for LTFs in Tucson.

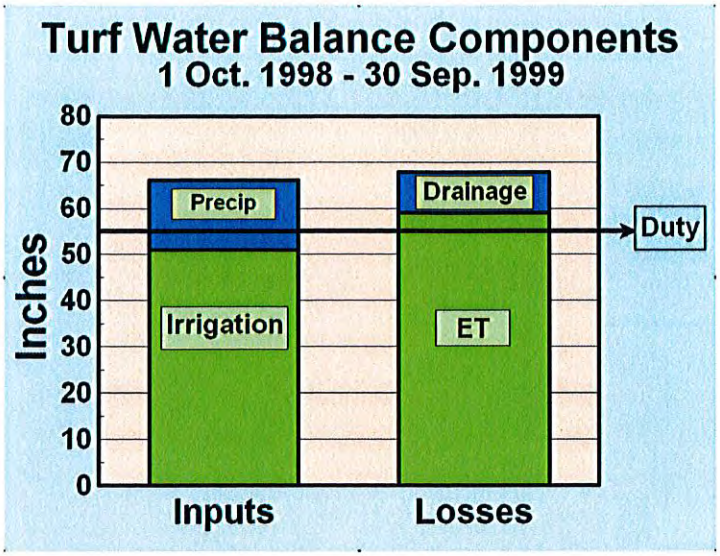

Figure 3. Components of the soil water balance for TY99. The arrow indicates the quantity of water provided in ADWR's water duty for LTFs in Tucson.

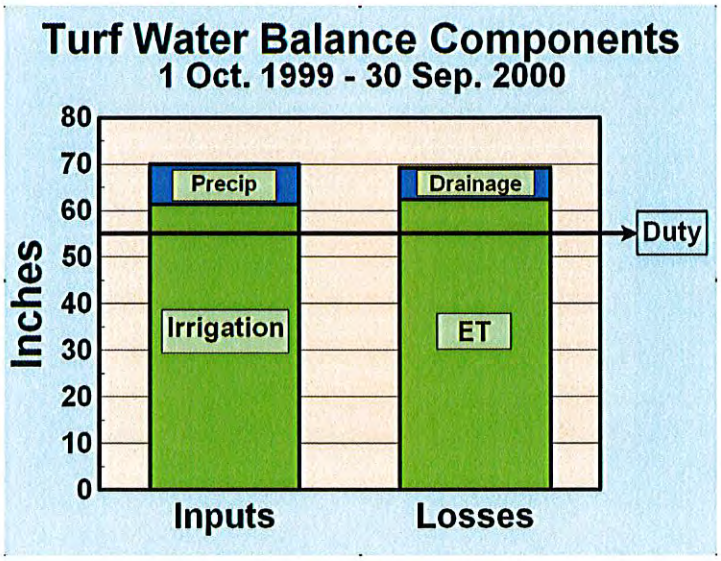

Figure 4. Components of the soil water balance for TY00. The arrow indicates the quantity of water provided in ADWR's water duty for LTFs in Tucson.

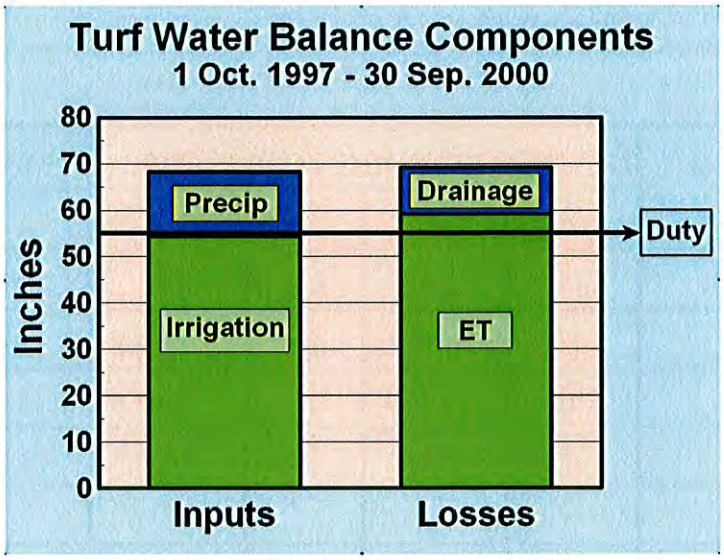

Figure 5. Components of the soil water balance for the period 1 Oct 1997 to 30 Sep 2000. The arrow indicates the quantity of water provided in ADWR's water duty for LTFs in Tucson.

Table 1. Summary of turf water balance components for TY98. Individual components consisting of irrigation, precipitation, drainage, ETt, and change in soil moisture storage are presented in units of inches and mm for each lysimeter. Mean values for each component are presented in the last two columns of the table and represent the average of the two lysimeters.

Components of Water Balance	LYSIMETER IRRIGATED WITH...				Mean Values	
	Groundwater		Effluent			
Inputs of Water	In	mm	In	mm	In	mm
Irrigation	51.0	1296.7	50.9	1292.6	51.0	1294.6
Precipitation	17.6	448.4	17.8	451.0	17.7	449.7
Total Inputs	68.7	1745.1	68.6	1743.6	68.7	1744.3
Losses of Water						
Drainage	16.4	417.6	12.5	317.0	14.5	367.3
ETt	55.2	1402.5	57.2	1453.6	56.2	1428.0
Total Losses	71.7	1820.1	69.7	1770.6	70.7	1795.3
Change in Storage	-3.0	-75.0	-1.1	-27.0	-2.0	-51.0

Table 2. Summary of turf water balance components for TY99. Individual components consisting of irrigation, precipitation, drainage, ETt and change in soil moisture storage are presented in units of inches and mm for each lysimeter. Mean values for each component are presented in the last two columns of the table and represent the average of the two lysimeters.

Components of Water Balance	LYSIMETER IRRIGATED WITH...				Mean Values	
	Groundwater		Effluent			
Inputs of Water	In	mm	In	mm	In	mm
Irrigation	51.9	1319.3	50.1	1272.8	51.0	1296.0
Precipitation	15.2	384.9	15.1	384.5	15.1	384.7
Total Inputs	67.1	1704.2	65.2	1657.3	66.2	1680.8
Losses of Water						
Drainage	10.2	257.9	7.4	187.2	8.8	222.6
ETt	59.1	1500.0	59.0	1499.5	59.0	1499.8
Total Losses	69.3	1757.9	66.4	1686.7	67.8	1722.4
Change in Storage	-2.2	-53.7	-1.2	-29.4	-1.6	-41.6

Table 3. Summary of turf water balance components for TY00. Individual components consisting of irrigation, precipitation, drainage, ETt and change in soil moisture storage are presented in units of inches and mm for each lysimeter. Mean values for each component are presented in the last two columns of the table and represent the average of the two lysimeters.

Components of Water Balance	LYSIMETER IRRIGATED WITH...				Mean Values	
	Groundwater		Effluent			
Inputs of Water	In	mm	In	mm	In	mm
Irrigation	61.6	1563.6	61.1	1552.6	61.3	1558.1
Precipitation	8.6	218.4	8.7	220.0	8.6	219.2
Total Inputs	70.2	1782.0	69.8	1772.6	70.0	1777.3
Losses of Water						
Drainage	7.7	196.4	5.6	142.7	6.7	169.6
ETt	61.9	1573.1	62.8	1595.6	62.4	1584.4
Total Losses	69.7	1769.5	68.4	1738.3	69.1	1754.0
Change in Storage	0.5	12.5	1.4	34.3	0.9	23.3

Table 4. Summary of turf water balance components for the three year period from 1 October1997 to 30 September 2000. Individual components consisting of irrigation, precipitation, drainage, ETt and change in soil moisture storage are presented in units of inches and mm for each lysimeter. Mean values for each component are presented in the last two columns of the table and represent the average of the two lysimeters.

Components of Water Balance	LYSIMETER IRRIGATED WITH...				Mean Values	
	Groundwater		Effluent			
Inputs of Water	In	mm	In	mm	In	mm
Irrigation	54.8	1393.2	54.0	1372.7	54.4	1383.0
Precipitation	13.8	350.6	13.8	351.8	13.8	351.2
Total Inputs	68.6	1743.8	67.9	1724.5	68.3	1734.2
Losses of Water						
Drainage	11.4	290.6	8.5	215.6	10.0	253.1
ETt	58.7	1491.9	59.7	1516.2	59.2	1504.0
Total Losses	70.2	1782.5	68.2	1731.9	69.2	1757.2
Change in Storage	-1.5	-38.7	-0.3	-7.4	-0.9	-23.0

Table 5. Turf evapotranspiration (ETt), reference evapotranspiration (ETo a), and the ratio of ETt to ETo a for TYs 98, 99, and 00.

YEAR	ETt		ETo a		Ratio (ETt:ETo a)
	In	mm	In	mm	
TY98	56.2	1427.5	74.5	1892.3	0.75
TY99	59.0	1498.6	78.4	1991.4	0.75
TY00	62.4	1585.0	82.8	2103.1	0.75
Mean	59.2	1503.7	78.6	1996.4	0.75

While annual values of ETt and ETo differed by as much as 6.2" (157.5 mm) and 8.3" (210.8 mm), respectively, the ratio of ETt to ETo averaged a consistent 0.75. This ratio is by definition a crop coefficient; thus, it appears that 0.75 serves as an excellent annual Kc value for a bermudagrass turf system that is overseeded in winter with ryegrass.

Amount of Applied Irrigation and Precipitation

The amount of irrigation water applied ranged from 51.0" (1296 mm) in both TY98 and TY99 to 61.3" (1558.1 mm) in TY00 and averaged 54.4" (1383 mm) over the period of study. During two years of the study and on average over the course of the study, the amount of irrigation water applied was less than the water duty of 55.2"/yr (1402 mm). Similar amounts of irrigation water were applied to each lysimeter during individual turf years and over the course of the study (Tables 1-4). The large difference in the level of irrigation water applied between TYs 98 and 99, and TY00 results from differing levels of precipitation. Above normal precipitation was recorded at the study site in both TYs 98 and 99 and helped to lower irrigation demand. In contrast, precipitation was below normal during TY00 when irrigation demand was highest. It is also interesting to note the impact of precipitation on evaporative demand as indicated by ETo. ETo totaled 74.5" (1892.3 mm), 78.4" (1991.4 mm) and 82.8" (2103.1 mm) during TYs 98, 99 and 00 when precipitation totaled 17.7" (449.7 mm), 15.1" (384.7 mm) and 8.6" (219.2 mm), respectively. A more in-depth evaluation of the relationship between precipitation and ETo was performed using 15-17 years of data available from AZMET. This analysis confirmed an inverse relationship between annual values of precipitation and ETo exists in both the Tucson and Phoenix areas, suggesting precipitation impacts the amount of applied irrigation water in both a direct and indirect manner. The direct impact is obvious as precipitation replaces water that would otherwise come from irrigation. The less obvious indirect impact is that precipitation with its associated cloudiness and higher humidity lowers ETo.

Drainage and Leaching Fractions

Drainage or water lost to deep percolation serves as the final important component of the water balance. Drainage is required to minimize the accumulation of soluble salts in the root zone and thereby avoid salinity problems. Drainage ranged from 6.7" (169.6 mm) during TY00 to 14.5"(367.3 mm) during TY98 and averaged 10.0"/yr (253.1 mm/yr) over the course of the study. The high rates of drainage in TY98 appear to include some residual drainage from the previous study where higher rates of irrigation maintained soil moisture at higher levels. Changes in stored soil moisture suggest this residual drainage totaled -2.0" (-51.0 mm) in TY98 (see next section).

Proper assessment of drainage requires one to convert drainage values to leaching fractions and then assess for a given turfgrass and irrigation water quality whether the leaching fraction is adequate. The leaching fraction is defined as the fraction of applied water that passes through the entire root zone and is lost to deep percolation. Leaching fractions for TYs 98, 99, and 00 were 0.21, 0.13, and 0.096, respectively, and averaged 0.15 during the entire period of study. Bermudagrass is rated as tolerant to salinity while ryegrass is rated as moderately tolerant; both grasses therefore have a low leaching requirement when irrigated with good quality water. The electrical conductivity of the irrigation water used in this study averaged 0.4 dS/m for the lysimeter irrigated with groundwater and 1.0 dS/m for the lysimeter irrigated with effluent. The resulting leaching requirements for bermudagrass irrigated with groundwater and effluent were 0.012 and 0.03, respectively. The leaching requirements for ryegrass equal 0.014 and 0.037 when using groundwater and effluent, respectively. Leaching was clearly adequate to avoid salinity problems in this study.

Changes in Soil Moisture Storage

Stored soil moisture remained fairly constant over the course of the study. Over the three years of study, moisture storage declined 0.9" (-23 mm). Annual changes in soil moisture storage ranged from -2.0" in TY98 to +0.9" in TY00. It is important to realize that these changes in soil moisture pertain to the entire lysimeter soil profile which has a depth of 12.3' (3.75 m). The total amount of soil moisture storage in the lysimeter profile at field capacity is ~17.7" (450 mm); thus, the annual changes in soil moisture storage represent no more than 12% of soil moisture at field capacity. The largest decline in soil moisture storage occurred at the beginning of TY98 and may reflect some residual drainage from the previous study where higher rates of irrigation maintained soil moisture at higher levels.

Translation of Results to Large Turf Facilities

The results presented in the previous section of this report appear to provide good evidence that ADWR water duties when combined with normal to above normal levels of precipitation provide sufficient water to support year round green turf while preventing future problems associated with excessive soil salinity. However, such a conclusion may be called into question when one attempts to transfer these results to LTFs. One important issue impacting the translation of these results to LTFs pertains to the procedures used to quantify the amount of applied irrigation water in this study. The daily gain in lysimeter mass during the brief (~15 minute) early morning irrigation window was used as the daily irrigation rate. In effect, this methodology measures the amount of water reaching the turf, not necessarily the total amount of water used in the irrigation process. This is an important distinction since ADWR monitors water used at the well head or diversion point, not water that reaches the turf. The amount of irrigation water reaching turf is always less than the water used at the well head or diversion point due to system leaks, evaporation while the water is in transit from the irrigation head to the turf, and drift off target (to non-turf areas). These losses of water along with other losses associated with runoff and deep percolation represent the main factors impacting irrigation efficiency which can be

defined as the percentage of total applied water that is put to beneficial use.

Another irrigation related factor that may impact the translation of these results to LTFs relates to irrigation non-uniformity. No irrigation system applies water over an area in a perfectly uniform manner. This non-uniformity is assessed via an irrigation audit which involves setting out an array of catch cans prior to an irrigation event to quantify the variation in precipitation resulting from system operation. Irrigation audits were run on the lysimeter irrigation systems and non-uniformity averaged 0.93 using Christiansen's Uniformity Coefficient (Christiansen, 1942). While it is common to increase irrigation run time to offset non-uniform irrigation, such a strategy was not employed in this study. Given that we did not observe any serious problems with turf performance in this study, it is tempting to assume that the results of this study are valid for irrigation systems exhibiting CU values approaching 0.90. However, it is questionable whether one can directly extrapolate the relationship between turf performance and irrigation non-uniformity found in small plots such as the lysimeters to LTFs. One reason such an extrapolation is unreasonable is that the high CU values obtained in this study are difficult (if not impossible) to replicate for LTF irrigation systems. A second reason such an extrapolation is questionable is that in small plots, turf root systems may be able to exhibit sufficient horizontal growth to offset the apparent limitations associated with non-uniform irrigation. For example, if 10% of the lysimeter received insufficient irrigation to support optimal growth, the total area under watered would be 5.3 ft^2 (0.5 m^2). If the entire under watered area was located in one square block of turf, the dimension of the block would be 2.3' x 2.3'(0.7 m x 0.7 m). Presumably, the turf in this small block could extend its roots outward in an horizontal manner and pick up water from adjacent areas receiving higher watering rates and turf performance would not greatly suffer. If however this same scenario is used on a 4-acre golf fairway, the area under watered is 17424 ft^2. If this under watered area were divided into 10 blocks of equal size (174.2 ft^2), then the dimensions of the block would be 13.2' x 13.2' (4 m x 4 m). In this case, it is unlikely turf in the middle of the block would be able to extend its root system into adjacent areas for supplemental water and thus would remain stressed and exhibit a lower visual quality.

One final issue that may impact translation of study results to LTFs involves topography and soil type. The lysimeter facility provides an experimental setup consisting of a level turf surface combined with a soil that supports a high water infiltration rate. This combination provides a best case scenario for infiltration of both irrigation water and precipitation. Often, LTFs must contend with one or both of the following features: 1) complex topographical features that include areas with steep slopes, and 2) soils with either fine textured or compacted surface layers that do not support high rates of water infiltration. These real world topographical and soil infiltration characteristics will lead to higher rates of runoff during irrigation and rainfall events with the overall impact being a reduction in available water supply for turf.

The previous paragraphs present what appears to be a conflict between what the study results indicate is possible in small plot studies versus the practical realities of translating these results to LTFs. To help clarify this conflict, a simple model was devised to assess the overall water balance of a unit area of turf in a LTF setting in the Tucson and Phoenix areas. The model estimates the net water balance of a turf area subjected to three scenario climate regimes (dry, normal, and wet) when irrigation system performance and runoff limit the amount of water that infiltrates the soil supporting the turfgrass. Input data required to run the model are presented in Table 6 and include precipitation, ETt, and the amount of water available from ADWR water duties. Wet and dry years were assigned precipitation values equal to 133% and 67% of normal, respectively. Annual values of ETt were assumed equal to 75% of EToa. EToa for the three precipitation regimes was determined from least squares regression lines relating annual EToa to annual precipitation for the Tucson and Phoenix areas.

The model projects the net water balance for the turf system when various percentages of the available water supply (irrigation water and precipitation) infiltrate the soil supporting the turf. Runoff from precipitation events was allowed to range from 0 - 50% of the annual precipitation amount in increments of 10%. The model assumes a LTF applies 100% of its allotted duty through the irrigation system but varies the percentage of this water that infiltrates into the unit area of turf from 75-100% in 5% increments. The output from the model is the net water balance (WB) for the turf system which is defined as the amount of irrigation (I) and precipitation (P) water that enters the turf system minus the ETt for the year:

$$WB = (f_i * I + f_p * P) - ETt \qquad (2)$$

where:

WB is the annual water balance of the unit turf area (in or mm)

f_i is the fraction of irrigation water duty that infiltrates into the turf area

I is the amount of water applied via irrigation (ADWR water duty, in or mm)

f_p is the fraction of precipitation that infiltrates into the turf area

P is the annual amount of precipitation (in or mm)

ETt is the annual rate of turf evapotranspiration (in or mm)

Positive water balance values indicate a surplus of available water. This surplus water, if actually applied, would be lost to deep percolation and thus assist with control of soil salinity. Negative balances indicate an insufficient water supply which may generate less acceptable turf and inadequate leaching to prevent the buildup of soil salinity.

Table 6. Input data used to model turf water balances at LTFs in the Tucson and Phoenix AMAs.

Location	Water Duty		Precipitation Regime						Turf Evapotranspiration (ETt)					
			Dry		Normal		Wet		Dry		Normal		Wet	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
Tucson	55.2	1402	8	203	12	305	16	404	59.4	1509	57.3	1455	55.2	1402
Phoenix	58.8	1494	5	127	7.5	190	10	254	58.3	1481	57.6	1463	56.9	1445

Turf Water Balance Estimates: Tucson

The results of this modeling effort for the Tucson area are presented in Table 7. Model scenarios that generated surpluses in the water balance are presented in blue text while scenarios generating deficits in the water balance are presented in red text. One immediate observation from Table 7 is the impact of precipitation on the water balance of the turf. During dry years, the water balance of the turf system is negative under nearly all water supply scenarios with the exception of situations where a LTF irrigation system can deliver 95-100% of the water duty to the turf. As indicated earlier in this report, evaporation, drift off target, runoff and leaks ensure that a facility will not be able to apply 100% of the water duty to the turf system.

The water balance improves substantially when precipitation is normal for the year. LTFs irrigation systems that can deliver a high percentage of the water duty to the turf and are not subjected to severe problems with runoff would be able to maintain a positive water balance in years with near normal precipitation. Facilities that can not deliver a high fraction of the water duty to the turf or have significant problems with infiltration would likely encounter a soil moisture deficit in normal years.

The soil water balances are generally positive in wet years. Presumably, most LTFs could maintain a positive water balance in these wet years. Only LTFs with very difficult infiltration problems or problem irrigation systems would be expected to run a deficit in wet years.

Turf Water Balance Estimates: Phoenix

The results of this modeling effort for the Phoenix area are presented in Table 8. The scenario precipitation regimes did not impact the Phoenix turf water balance estimates to the same degree as was observed for the Tucson area. Two factors explain why the Phoenix estimates are not as responsive to the precipitation regimes: 1) the difference in precipitation between regimes was just 2.5" compared with 4.0" for Tucson; and 2) the impact of annual precipitation on ETt is not as large in Phoenix as in Tucson. Nevertheless, the trend at Phoenix still follows the general trend observed for Tucson. During dry years, only LTFs with irrigation systems that can deliver 95-100% of the water duty would be able to maintain a positive water balance.

The additional 2.5" of precipitation expected in a normal year in Phoenix improves the water balances only slightly. LTFs with irrigation systems that can deliver 90% of the water duty to the turf and are not prone to severe runoff problems would be added to the group of LTFs that could sustain positive turf water balances. Wet years produce further improvements in turf water balances, but the results suggest LTFs that can not deliver in excess of 80% of the water duty to the turf, or are subject to severe problems with infiltration would continue to run a water deficit in wet years.

It is important to note when examining the results of this modeling exercise that the model does not directly address the issue of irrigation non-uniformity. The results are for turf areas receiving irrigation at the mean precipitation rate of the irrigation system (some fraction of 4.6 (Tucson) or 4.9 (Phoenix) af/a/yr). In reality, approximately half the area would receive more than the mean precipitation rate and would produce a more positive water balance while the other half of the area will receive less than this mean rate, thus generating a less favorable balance. A common engineering approach to this non-uniformity problem is to obtain a measure of non-uniformity from an irrigation audit and then increase the irrigation rate in a manner that minimizes the amount of area that is under watered. This approach generates very high levels of water use and often produces excessive wetness which can limit the usefulness or "playability" of turf. Many sports related LTFs do not use this approach to address irrigation non-uniformity because of: 1) playability issues and 2) water supply limitations (system capacity and/or water duties). Instead, these facilities "pull hoses" and hand water or extend run times on selected heads or zones to add moisture to drier areas. The water used in such "unscheduled" irrigations would count against the water duty and would lower the amount of water that could be applied via the irrigation system. If for example 5% of a LTF's total water duty was applied via unscheduled irrigations, then only 4.37 af/a (52.4" or 1332mm in Tucson) to 4.66 af/a (55.9" or 1419 mm in Phoenix) could be applied

Table 7. Projected turf water balances in inches and millimeters for LTFs in the Tucson AMA, assuming: 1) the indicated percentages of the annual water duty infiltrate the soil and 2) the indicated percentages of annual precipitation are lost to runoff. Results assume a LTF applies its entire water duty each year. See Table 6 for assumptions regarding annual rates of turf evapotranspiration (ETt) and precipitation. Positive water balances are presented in blue text; negative water balances are presented in red text.

P□□□□□□□□T□□□Water Balances: Tucson												
% of Duty Infiltrating Soil	% of Precipitation Lost to Runoff (Dry Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	3.8	97.5	3.0	77.1	2.2	56.7	1.4	36.3	0.6	15.8	-0.2	-4.6
95	1.1	27.4	0.3	7.0	-0.5	-13.4	-1.3	-33.8	-2.1	-54.3	-2.9	-74.7
90	-1.7	-42.7	-2.5	-63.1	-3.3	-83.5	-4.1	-103.9	-4.9	-124.4	-5.7	-144.8
85	-4.4	-112.8	-5.2	-133.2	-6.0	-153.6	-6.9	-174.0	-7.7	-194.5	-8.5	-214.9
80	-7.2	-182.9	-8.0	-203.3	-8.8	-223.7	-9.6	-244.1	-10.4	-264.6	-11.2	-285.0
75	-10.0	-253.0	-10.8	-273.4	-11.6	-293.8	-12.4	-314.2	-13.2	-334.7	-14.0	-355.1
% of Duty Infiltrating Soil	% of Precipitation Lost to Runoff (Normal Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	9.8	249.9	8.6	219.5	7.4	189.0	6.2	158.5	5.0	128.0	3.8	97.5
95	7.1	179.8	5.9	149.4	4.7	118.9	3.5	88.4	2.3	57.9	1.1	27.4
90	4.3	109.7	3.1	79.2	1.9	48.8	0.7	18.3	-0.5	-12.2	-1.7	-42.7
85	1.6	39.6	0.4	9.1	-0.8	-21.3	-2.0	-51.8	-3.2	-82.3	-4.4	-112.8
80	-1.2	-30.5	-2.4	-61.0	-3.6	-91.4	-4.8	-121.9	-6.0	-152.4	-7.2	-182.9
75	-4.0	-100.6	-5.2	-131.1	-6.4	-161.5	-7.6	-192.0	-8.8	-222.5	-10.0	-253.0
% of Duty Infiltrating Soil	% of Precipitation Lost to Runoff (Wet Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	16.0	405.4	14.4	364.8	12.8	324.3	11.2	283.8	9.6	243.2	8.0	202.7
95	13.2	335.3	11.6	294.7	10.0	254.2	8.4	213.7	6.8	173.1	5.2	132.6
90	10.4	265.2	8.8	224.6	7.2	184.1	5.7	143.6	4.1	103.0	2.5	62.5
85	7.7	195.1	6.1	154.5	4.5	114.0	2.9	73.5	1.3	32.9	-0.3	-7.6
80	4.9	125.0	3.3	84.4	1.7	43.9	0.1	3.4	-1.5	-37.2	-3.1	-77.7
75	2.2	54.9	0.6	14.3	-1.0	-26.2	-2.6	-66.8	-4.2	-107.3	-5.8	-147.8

Table 8. Projected turf water balances in inches and millimeters for LTFs in the Phoenix AMA, assuming: 1) the indicated percentages of the annual water duty infiltrate the soil and 2) the indicated percentages of annual precipitation are lost to runoff. Results assume a LTF applies its entire water duty each year. See Table 6 for assumptions regarding annual rates of turf evapotranspiration (ETt) and precipitation. Positive water balances are presented in blue text; negative water balances are presented in red text.

Project Tur□Water Balances: P□beni□												
% o□Dut□ In□iltratin□ Soil	% o□Precipitation Lost to Runo□□(Dr□Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	5.5	140.2	5.0	127.4	4.5	114.6	4.0	101.8	3.5	89.0	3.0	76.2
95	2.6	65.5	2.1	52.7	1.6	39.9	1.1	27.1	0.6	14.3	0.1	1.5
90	-0.4	-9.1	-0.9	-21.9	-1.4	-34.7	-1.9	-47.5	-2.4	-60.4	-2.9	-73.2
85	-3.3	-83.8	-3.8	-96.6	-4.3	-109.4	-4.8	-122.2	-5.3	-135.0	-5.8	-147.8
80	-6.2	-158.5	-6.7	-171.3	-7.2	-184.1	-7.8	-196.9	-8.3	-209.7	-8.8	-222.5
75	-9.2	-233.2	-9.7	-246.0	-10.2	-258.8	-10.7	-271.6	-11.2	-284.4	-11.7	-297.2
% o□Dut□ In□iltratin□ Soil	% o□Precipitation Lost to Runo□□(Normal Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	8.6	219.5	7.9	200.6	7.2	181.7	6.4	162.8	5.7	143.9	4.9	125.0
95	5.7	144.8	5.0	125.9	4.2	107.0	3.5	88.1	2.7	69.2	2.0	50.3
90	2.8	70.1	2.0	51.2	1.3	32.3	0.5	13.4	-0.2	-5.5	-1.0	-24.4
85	-0.2	-4.6	-0.9	-23.5	-1.7	-42.4	-2.4	-61.3	-3.2	-80.2	-3.9	-99.1
80	-3.1	-79.2	-3.9	-98.1	-4.6	-117.0	-5.4	-135.9	-6.1	-154.8	-6.8	-173.7
75	-6.1	-153.9	-6.8	-172.8	-7.5	-191.7	-8.3	-210.6	-9.0	-229.5	-9.8	-248.4
% o□Dut□ In□iltratin□ Soil	% o□Precipitation Lost to Runo□□(Wet Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	11.9	301.8	10.9	276.5	9.9	251.2	8.9	225.9	7.9	200.6	6.9	175.3
95	8.9	227.1	7.9	201.8	6.9	176.5	6.0	151.2	5.0	125.9	4.0	100.6
90	6.0	152.4	5.0	127.1	4.0	101.8	3.0	76.5	2.0	51.2	1.0	25.6
85	3.1	77.7	2.1	52.4	1.1	27.1	0.1	1.8	-0.9	-23.5	-1.9	-48.8
80	0.1	3.0	-0.9	-22.3	-1.9	-47.5	-2.9	-72.8	-3.9	-98.1	-4.9	-123.4
75	-2.8	-71.6	-3.8	-96.9	-4.8	-122.2	-5.8	-147.5	-6.8	-172.8	-7.8	-198.1

through the irrigation system. Because the hand watering would be targeted for areas receiving less than the mean precipitation rate, the water balances presented in Tables 7 & 8 would be less favorable by an amount approaching 2.5" (64 mm).

Concluding Remarks

The results of this study provide additional evidence that ADWR turf water duties provide significant challenges for LTFs that wish to maintain a year round green turf surface. Turf ET over the course of the three year study averaged 59.2"/yr (1504 mm/yr) or 4"/yr (101.6 mm/yr) above the current water duty for the Tucson area. The amount of water supplied via irrigation averaged 54.4"/yr (1383 mm/yr)) or 0.8"/yr (20.3 mm/yr) less that the ADWR water duty. Precipitation supplied the additional water required to: 1) prevent to development soil moisture deficits and 2) support deep percolation required to minimize the buildup of salinity. While the study results suggest that ADWR water duties supply adequate water to sustain year round turf in the Tucson area, when the study results are adjusted to accommodate runoff during precipitation events and the inefficiencies in LTF irrigation systems (e.g., leaks, evaporation, drift, non-uniformity), precipitation becomes the critical factor that determines whether the ADWR water duty is adequate to support year round turf. Results from a simple water balance model suggest the water duties will prove inadequate for nearly all Tucson and Phoenix LTFs in dry years. The adequacy of the water duties in normal years appears to be "facility dependent" in both locations. LTFs with efficient irrigation systems and soils that support high rates of infiltration could get by with the water duty in years with normal precipitation. Facilities with less efficient irrigation systems and/or soil with poor infiltration characteristics would likely find the duties inadequate in normal years. In wet years, modeling efforts indicate the water duties should be adequate for most LTFs in the Tucson area, but remain "facility dependent" in the Phoenix area.

Future Research Needs

The modeling effort used to translate the results of this study to LTFs reveals several important issues that must be resolved to make a more definitive statement regarding the adequacy of ADWR water duties for turfgrass. One issue pertains to the fraction of pumped or diverted water that reaches the turf surface in a well managed and maintained irrigation system. As stated earlier, leaks, drift off target and evaporation (while water is in transit from the irrigation head to the turf) are the potential causes for such losses. The modeling results in Tables 7 and 8 indicate such losses play a critical role in determining the adequacy of the water duties. Results from some preliminary UA studies and comments from other researchers in turf irrigation indicate losses approaching 20% are not uncommon. If such losses do approach 20%, then the water duties would prove inadequate in most circumstances (see Tables 7 & 8). Studies that can accurately quantify these losses represent an important area of future research.

Salinity represents the second important issue of importance for the future. The modeling results presented in Tables 7 & 8 indicate whether the annual balance between water supply and water use is positive or negative. A positive balance would support deep percolation and minimize problems with soil salinity. Model scenarios that predict a negative water balance would indicate deep percolation is inadequate, thus leading to future problems with salinity. As indicated earlier in this report, irrigation non-uniformity will ensure that close to half of the turf at a LTF will receive less than the mean rate of irrigation indicated in Tables 7 and 8. Such areas should be more vulnerable to the buildup of soil salinity and will likely exhibit higher levels of soil salinity. An assessment of soil salinity at LTFs should therefore provide additional important information regarding the adequacy of ADWR turf water duties. If these assessments reveal evidence of salinity problems (e.g., high levels of surface soil salinity and inverted soil salinity profiles) at LTFs employing efficient irrigation practices, such results would indicate the water duty is inadequate to support year round turf.

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THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
TUCSON, ARIZONA 85721

PAUL W. BROWN
Extension Specialist, Biometeorology

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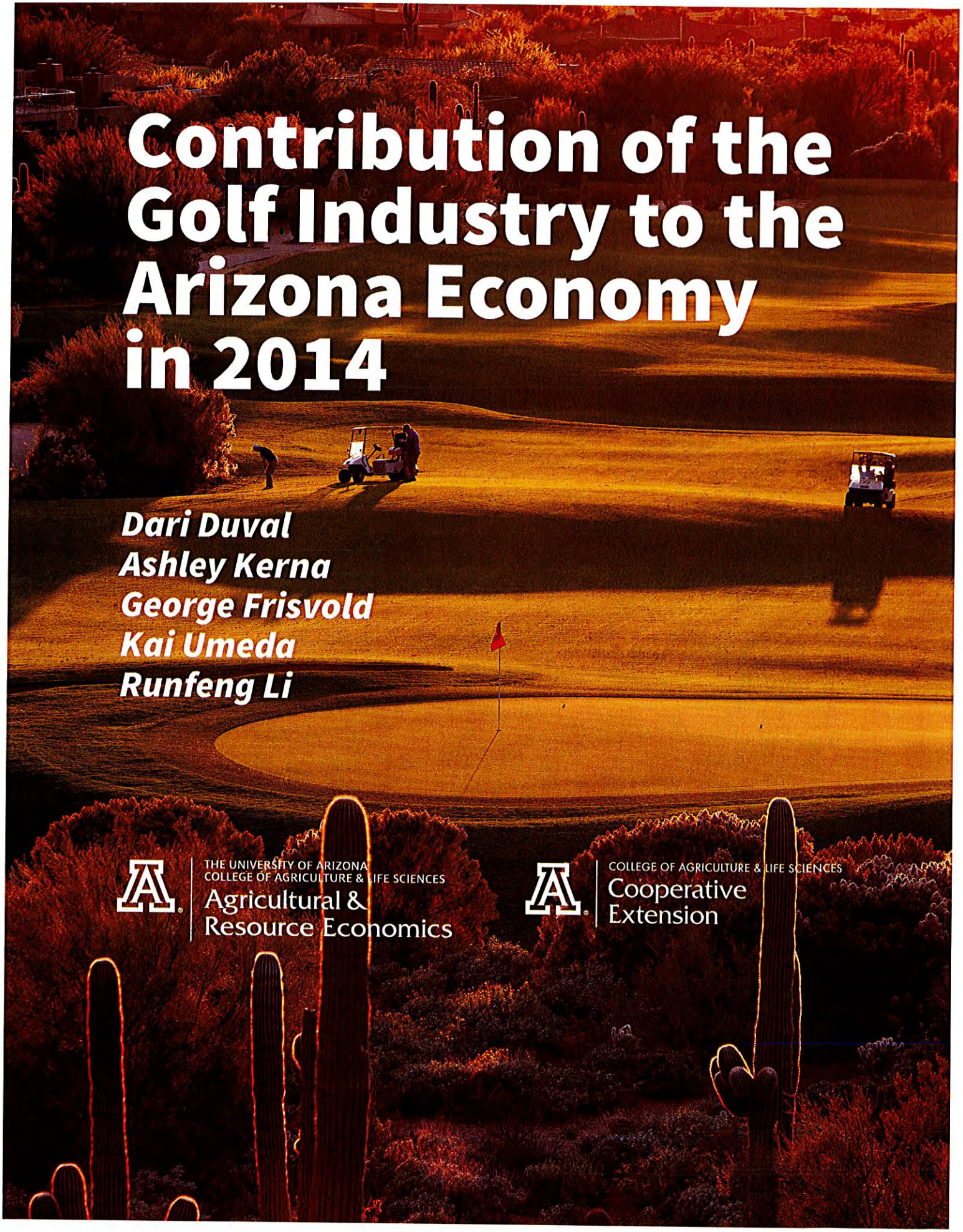

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Dari Duval
Economic Impact Analyst

Ashley Kerna
Economic Impact Analyst

George Frisvold
Professor and Extension Specialist

Kai Umeda
Extension Specialist

Runfeng Li
Graduate Research Assistant

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Communication Links	$500
Paradise Valley Country Club	$500

Executive Summary

What Is the Issue?

Golf is an important part of Arizona's economy and a defining component of the physical landscape of many of its cities and towns. Golf facilities support jobs and income for the state economy, indirectly support other Arizona businesses that serve and supply the facilities, drive tourist spending by attracting visitors from outside the state, and support sales by retailers offering golf equipment and merchandise to Arizona golfers. Additionally, golf facilities exert a positive effect on the value of residential real estate in their proximity. Meanwhile, golf courses require inputs year-round to maintain playable and attractive conditions for golfers on the facility's turfgrass and other landscape surfaces. Major inputs include irrigation water, fertilizer, and other agricultural chemicals. Conservation efforts at golf facilities aim to balance the use of natural resources with the economic viability of the courses.

This study provides an estimate of the economic contribution of the golf industry to Arizona's economy in 2014, examining the following components:

- Golf facility operations (operations spending, jobs, and other contributions)
- Golf-related tourist spending
- Golf-related business revenues

This report uses a variety of metrics to describe the golf industry's contribution to the Arizona economy. These include sales (output), value added (GDP), labor income (employee compensation and proprietor income), jobs, and state and local taxes. It's important to note that many of these economic metrics are interconnected and, therefore, cannot be added together. Furthermore, while sales (output) is an easily-interpreted measure of economic activity, value added (also known as gross state product) is the best reflection of an industry's contribution to the state economy.

The contribution of the golf industry to Arizona's economy goes beyond the **direct effects** of facility revenues, tourist spending, and golf-related business sales. The businesses providing those goods and services also require inputs of goods and services in order to operate, many of which are supplied by in-state suppliers. Those local businesses in turn require their own production inputs. These rounds of business-to-business transactions of providing inputs are known as **indirect effects**. Additionally, incomes (wages, salaries, and profits) generated for individuals employed directly by the golf industry are used to purchase household needs, such as rent or mortgages, doctor visits, and groceries. This spending produces rounds of household-to-business transactions, known as **induced effects**. Because of these indirect and induced multiplier effects, the economic contribution of the golf industry in Arizona is considerably greater than indicated by direct sales and tourist spending.

Other effects of the golf industry are not best measured using regional economic contribution analysis. These effects include the influence of golf courses on residential real estate values and natural resource use and conservation. The study provides an update to a 2004 estimate of residential real estate premiums attributable to frontage on and proximity to golf courses, and provides a snapshot of golf water use and conservation and management practices at Arizona golf facilities in 2014.

What Did the Study Find?

Arizona's golf industry had a total estimated economic contribution of $3.9 billion in sales (output) to the state economy in 2014. This includes the direct,

indirect, and induced effects of golf course operations ($2.5 billion), golf tourism ($1.1 billion), and golf-related businesses ($347 million).

Economic Contribution

- **Golf facility operations** generated a direct contribution of $1.1 billion in sales to the state economy in 2014, directly supporting an estimated 18,695 full- and part-time jobs. Including multiplier effects, the total contribution was $2.5 billion in sales, $1.4 billion in value added (gross state product), and approximately 29,500 full- and part-time jobs. An estimated $72 million in state and local taxes was directly supported, including $39 million in direct state and local sales tax revenues. An estimated 11.6 million rounds of golf were played in Arizona in 2014.
- **Golf tourism**, both golf travelers and golf spectators, attracted an estimated $598 million in spending from out-of-state visitors in 2014, for a total estimated impact of $1.1 billion in sales and approximately 10,500 jobs. Direct sales tax impacts were estimated at $32 million in 2014. Roughly a third of rounds played in Arizona in 2014 were by out-of-state and out-of-country visitors.
- **Golf-related businesses**, such as equipment and apparel retailers, practice ranges, and golf cart dealers, had estimated annual sales of $270 million, for a total estimated contribution of $347 million in sales, approximately 1,800 jobs, and directly-supported sales tax revenues of $6.5 million.

Residential Real Estate Premiums

- Hedonic studies have shown that frontage on and proximity to golf courses is associated with a sales price premium for residential real estate.
- Residential real estate premiums associated with all homes ever built in golf course communities in Arizona were estimated to be nearly $2.1 billion.

Water Use

- **Survey Results**
  - *Statewide use*—According to survey results, Arizona golf facilities used an estimated 167,397 acre-feet (AF) of irrigation water in 2014, occupying a total of 45,000 acres for the golf courses, of which 32,000 acres was turfgrass.
  - *Use of effluent*—Statewide, according to survey results from this study, an estimated 35% of golf water use was effluent in 2014. This percentage from the survey is somewhat higher than estimates from water resource agencies (see below).

- **USGS Statewide Data (2010)**
  - *Statewide use*—In 2010, 130,116 AF of self-supplied freshwater was used to irrigate golf courses, accounting for 1.9% of Arizona's total freshwater withdrawals. This figure includes groundwater and surface water, but excludes effluent.
  - *Use of effluent*—Statewide, 49,488 AF of reclaimed wastewater was used for golf course irrigation in 2010, accounting for 28% of golf's total statewide water use.
  - *Share of statewide use by source*—In 2010, golf irrigation accounted for 3% of state groundwater withdrawals and 1.1% of state surface water withdrawals, but 34% of state reclaimed water use for irrigation.

- **ADWR Active Management Area (AMA) Data**
  - *Share of statewide AMA use*—According to Arizona Department of Water Resources (ADWR) data, golf water use represented 3.5% of total AMA water use in Arizona in 2014.
  - *Breakdown of golf AMA use by source*—In 2014, groundwater represented 48.1% of AMA golf water use, surface water, 10.9%, CAP, 14.6%, and effluent, 26.3%. Whereas some AMAs rely on a varied mix of water sources, others rely heavily on one or two sources, such as effluent or groundwater.
  - *Use of effluent*—Use of effluent by golf facilities in AMAs was 33,977 AF in 2014, an increase of 27% since 2004.
  - *10-year trend*—Between 2004 and 2014, ADWR reported a net increase of 24,736 AF of golf facility water use in Arizona's AMAs, with all types of water use increasing. During that time, the number of facilities in Arizona's AMAs also increased, from 239 facilities to 252 facilities.

Conservation Practices

- 51% of respondents reported performing irrigation audits for their golf course irrigation systems, and among respondents conducting irrigation audits, 95% made adjustments to their irrigation systems, for an average irrigation water savings of 19.5 AF of water per facility per year.
- 31% of respondents reported having removed turfgrass in the past 5 years. Another 39% reported having a partnership with conservation organizations, the most common of which was Audubon International.

How was the study conducted?

This study relies on the results of a statewide survey of golf facilities performed between April and August of 2016. In order to capture all components of golf facility operations, the survey was directed at three key staff positions at each facility: General Manager/Director of Club Operations, Head Golf Professional/Director of Golf, and Golf Course Superintendent/Director of Agronomy. The survey response rate was 44% for General Managers, 26% for Golf Professionals, and 45% for Superintendents. With some unusable responses having been submitted, the useable response rate was 42% for General Managers, 25% for Golf Professionals, and 39% for Superintendents. Unbiased estimates were calculated from the survey response data using scaling and an expansion factor. Survey data were complemented with secondary data on golf business establishments, golf tourism, real estate, and golf water use from a variety of sources. The economic multiplier effects of the golf industry were estimated using IMPLAN 3.1, the premier input-output model used for regional economic impact analysis.

Introduction

Overview

Golf is an important part of Arizona's economy and a defining component of the physical landscape of many of its cities and towns. The golf industry supports jobs and incomes for the state economy, indirectly supports other Arizona businesses that serve and supply the facilities, drives tourist spending by attracting visitors from outside the state, and supports sales by retailers offering golf equipment and merchandise. Additionally, golf facilities exert a positive effect on the value of residential real estate in their proximity. Meanwhile, golf courses require inputs year-round to maintain playable and attractive conditions for golfers on the facility's turfgrass and other landscape surfaces. Major inputs include irrigation water, fertilizer, and other agricultural chemicals. Conservation efforts at golf facilities aim to balance the use of natural resources with the economic viability of the courses.

This study provides an estimate of the economic contribution of golf to Arizona's economy in 2014, examining the following components:

- Golf facility operations (spending, jobs, and other contributions)
- Golf-related tourist spending
- Golf-related businesses.

This estimate includes direct, indirect, and induced multiplier effects and is measured in terms of sales (output), value added (GDP), labor income (employee compensation and proprietor income), jobs, and state and local taxes.

Furthermore, the study provides an updated estimate of residential real estate price premiums attributable to proximity to golf courses. Finally, this study provides a snapshot of golf water use and conservation and management practices at Arizona golf facilities in 2014.

Motivation

This study provides an update to a 2006 study of the economic contribution of golf to the Arizona economy in 2004, "Economic and Environmental Impact of Golf" (Schmitz, 2006). It relies on primary data collected from Arizona golf facilities statewide through a survey, as well as secondary data from a variety of sources. A survey was necessary because government statistics do not capture golf facilities in one single industry. Businesses are typically captured in government statistics according to the industry that represents the majority of their sales. Therefore, golf facilities that are part of resort hotels are often categorized as hotels (NAICS[1] 721110). Golf facilities not associated with resorts are most typically classified as golf courses and country clubs (NAICS 713910). To rely only on statistics for golf courses and country clubs would significantly underrepresent the extent of the industry in the state, considering that many golf courses in Arizona are attached to resort properties. In addition to filling the gaps in government data, the survey provides an opportunity to better understand golf facility revenues and expenses, employment, and conservation and management practices used on the golf courses.

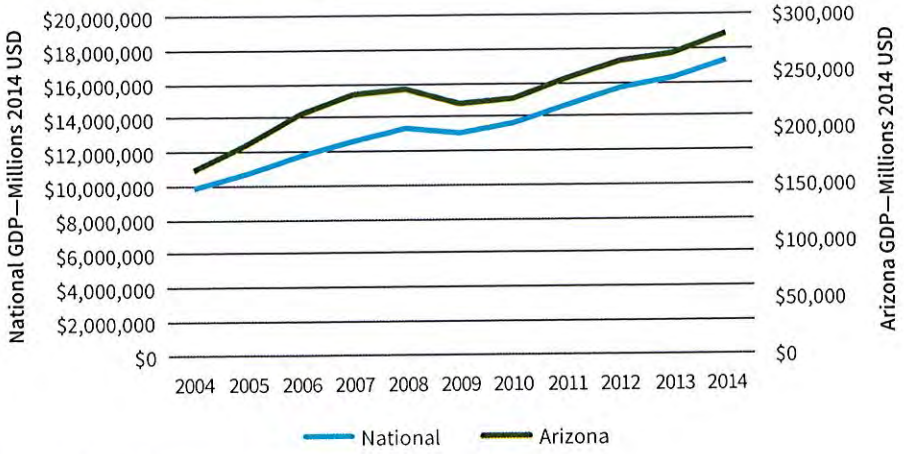
Economic and Industry Context

Since 2004, the date of the most recent analysis, the state and national economies have weathered great challenges as a result of the Great Recession.

1 North American Industry Classification System (NAICS) codes are 2 to 6 digit codes used for purposes of classifying business entities by their primary industry in government statistics (US Census Bureau, 2016).

Arizona was hit especially hard by the downturn, and golf, an activity linked closely with both disposable personal income as well as real estate, suffered heavily as a result. The state and national economies both experienced significant contractions between 2008 and 2009, as evidenced by gross domestic product and gross state product (Figure 1).

Figure 1. Arizona Gross State Product and US Gross Domestic Product 2004–2014, in Millions, Adjusted to 2014 Dollars

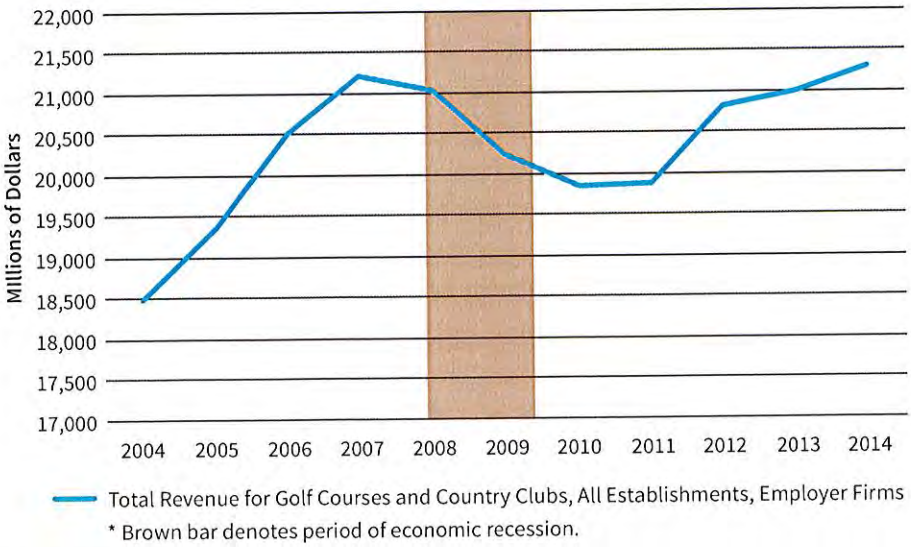


Source: Bureau of Economic Analysis, Bureau of Labor Statistics

At the national level, golf courses and country clubs saw a significant decline in revenues between 2007 and 2010 (Figure 2).

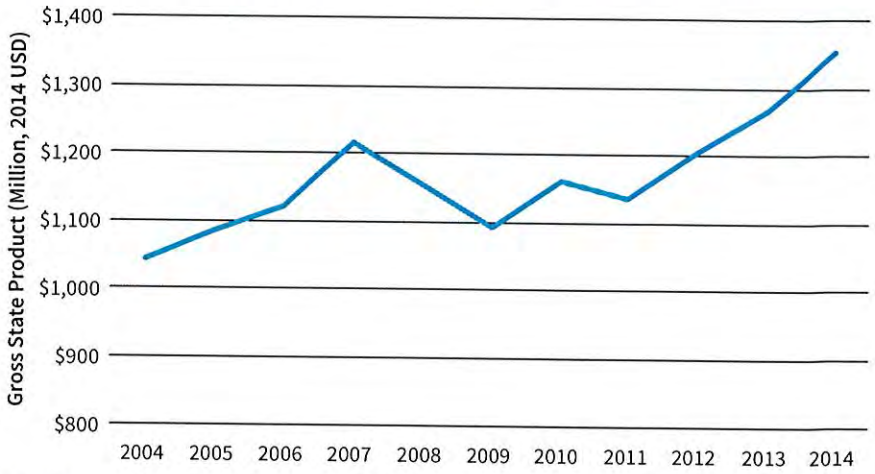
Amusements, gambling, and recreation industries' direct contribution to Arizona's gross state product, which includes golf courses and country clubs,

Figure 2. Total Revenues for Golf Courses and Country Clubs, United States, 2004–2014



Source: US Census Bureau

Figure 3. Gross State Product of Arizona Amusements, Gambling and Recreation Industries, 2004–2014, Adjusted to 2014 Dollars



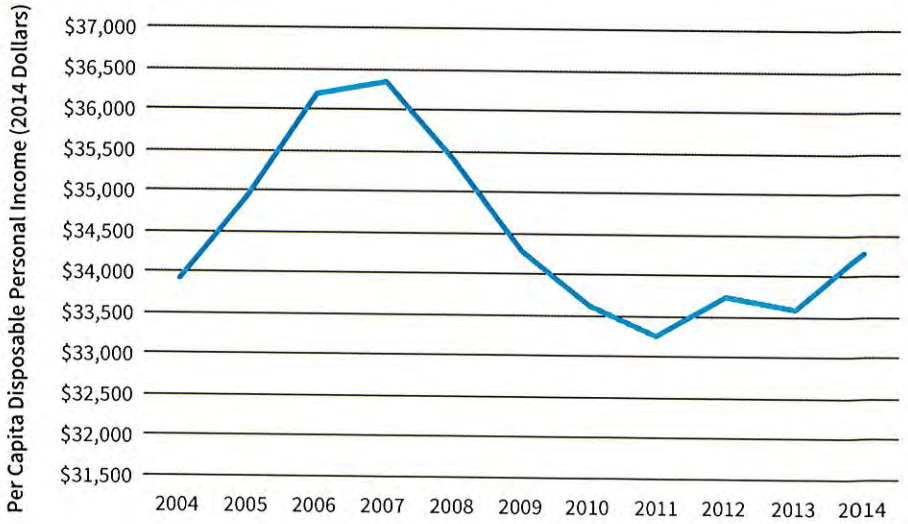
Source: Bureau of Economic Analysis; Bureau of Labor Statistics

experienced a considerable slump starting in 2007, but has since resumed growth since 2011 (Figure 3).

The economic downturn's effect on households in Arizona is evidenced by trends in per capita disposable income (Figure 4). After increasing to a sharp peak in 2007, Arizona per capita disposable personal income declined, bottoming out in 2011, and has gradually increased since that time.

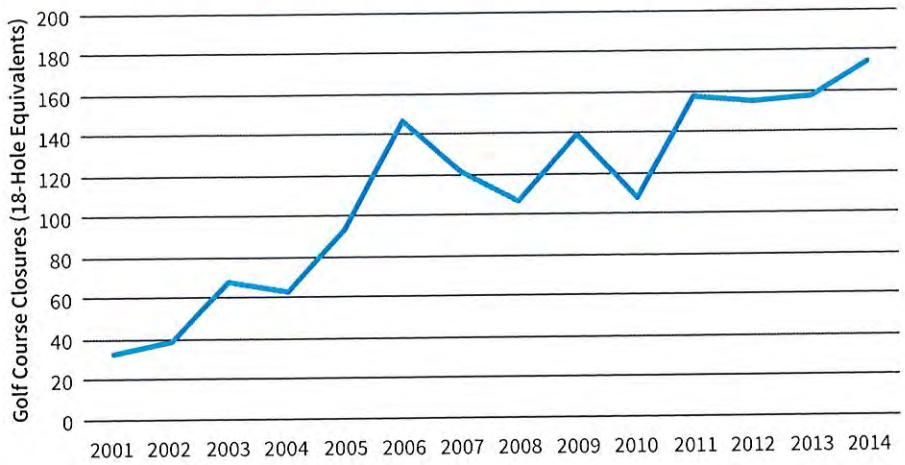
In recent years, the national supply of golf courses has been decreasing in what is considered a market correction after significant increases in golf course construction during the 1990s (Hueber & Worzala, 2010). Golf course closures in the U.S. began to increase in the early 2000s and have averaged

Figure 4. Arizona Per Capita Disposable Personal Income 2004–2014, Adjusted to 2014 Dollars



Source: Bureau of Economic Analysis, Bureau of Labor Statistics

Figure 5. National Golf Course Closures (18-Hole Equivalents), 2001–2014



Source: National Golf Foundation

140 closures per year between 2006 and 2014 (Figure 5). This, coupled with relatively low levels of new construction since that time, have led to a net reduction in the number of 18-hole equivalent courses in the U.S. The National Golf Foundation projects golf course openings in the U.S. to average 20 or fewer annually in the near future (NGF, 2013).

In Arizona, a similar trend has emerged with 17 facilities closing during that same period. Yet, an estimated 19 new golf facilities have opened between 2004 and 2014, resulting in a net increase of two facilities. This is not including facilities that have undergone significant renovations, closed and reopened, or transferred ownership since that time. Another important trend includes the privatization of public municipal courses. In recent years, such courses have struggled to remain financially solvent, prompting municipalities to sell to or partner with third-party management companies (Keegan, 2010). This trend has affected municipal courses in Arizona.

Methods and Data

Arizona Golf Facility Survey

This economic contribution analysis relies on the results of an online survey of golf facilities in Arizona. The survey collected information on the operations of Arizona golf facilities in calendar year 2014 with focused sections directed to three key staff positions at each facility:

- General Manager / Director of Club Operations (referred to herein as General Manager);
- Head Golf Professional / Director of Golf (referred to herein as Golf Professional);
- Golf Course Superintendent / Director of Agronomy (referred to herein as Superintendent).

The section answered by the General Manager concentrated on overall golf facility operations with questions pertaining to facility finances, investment, and employment. The section answered by the Golf Professional focused on tournaments and pro shop finances and purchasing. The section answered by the Superintendent included information on golf course maintenance expenses and practices, and in particular focused on turfgrass management and water conservation strategies. Finally, all three staff roles completed an initial survey section regarding general facility characteristics, including number of holes, county location, facility type, and other similar general characteristics. The survey was distributed by two means: an online survey distributed via email using the Qualtrics platform (Appendix A), as well as a hard-copy invitation letter mailed to facilities and addressed to the General Manager (Appendix B). The online survey was distributed via email invitations to a database of golf facility contacts whose emails were available through golf industry associations, as well as from facility websites. The survey invitation letter was sent via US Mail to all golf facilities in the state and included a URL for survey participants to follow where they could enter a password to access the survey.

The full database of Arizona golf facilities was compiled through a combination of sources, primarily the Arizona Golf Association and Golflink. The lists of facilities were combined, removing duplicates, and the information was validated, removing facilities that were no longer in operation, and compiling contact information. The database includes 313 separate facility listings. This survey and study were conducted at the facility level, with facilities varying in size and many having more than one golf course at the establishment.

The online survey was first activated and distributed on April 20, 2016 and remained open until August 5, 2016. The hard copy letter was mailed on April 20, 2016. A follow-up letter was mailed on May 18, 2016. Email reminders were sent periodically during the open period to those facilities that email contacts were available for. Survey invitations were also sent by Cactus and Pine Golf Course Superintendent (GCSA), the Southwest Section Professional Golf Association (PGA), and the Club Managers Association of America (CMAA) to their respective memberships. A survey incentive was coordinated through Cactus and Pine GCSA to drive participation in the first weeks of the survey. Participants were eligible for an optional raffle drawing if they participated before May 31, 2016.

Settings in Qualtrics were configured to remove any connection between a respondent's email and their survey response. The system provided an

anonymized unique identifier for each response. Similarly, the optional raffle was a separate survey with no connection to golf facility survey responses and raffle responses to preserve the anonymity of responses. The survey was reviewed by the University of Arizona's Human Subjects Protection Program and was determined not to constitute human research. Best practices were followed with regards to survey design, allowing respondents to opt out of any question, either by including questions where no response was required, or by including the option of "I prefer not to respond." After the survey closed, anonymized results data were downloaded and analyzed according to methods described in subsequent sections.

Statistical Methodology and Expansion Factor

The golf survey was divided into four sections. The first section asked all respondents to provide general characteristics of their facility. The other three sections were directed towards each role at the facility. The survey presented a combination of qualitative and quantitative responses.

Questions that presented yes-no options or asked respondents to select among multiple options were analyzed using a simple count method. These are questions where the response is not a number and therefore should not vary depending upon the size of the facility.

For those questions where respondents were asked to provide a number (revenues, rounds of golf, etc.), a scaling and expansion method was used to obtain an unbiased estimate of statewide values based on the survey sample, assuming that numerical responses (revenues, costs, acreage, etc.) are proportional to the size of the facility in terms of number of holes. For a full description of the scaling and expansion method, please consult Appendix C.

Golf-Related Tourism

Data from the survey regarding the percent of annual rounds played by geographic origin on the golfer were coupled with golf tourist expenditure and travel behavior data from two separate research reports to account for the contribution of golf tourists, as well as professional golf tournament spectators to the state economy.

Golf-Related Businesses

The golf-related businesses section of this study relies on a variety of secondary data sources, including ReferenceUSA, MelissaData, and Census Industry Snapshots. These data are used to produce an establishment count, as well as an estimate of annual revenues for those golf-related businesses whose economic activity is not captured through the survey response.

Economic Contribution Analysis

Integrating results from previous sections, the indirect and induced multiplier effects of golf facility operations, golf-related tourism, and golf-related businesses, were calculated using the IMPLAN 3.1 model and software in order to obtain a total economic contribution estimate. IMPLAN is an input-output model that captures the linkages between economic sectors through local buyer-supplier relationships, whereby purchases of goods and services from local providers across the supply chain create additional rounds of transactions in the economy, supporting additional sales, incomes, and jobs. Both business-to-business (indirect effects) as well as business-to-household (induced effects) transactions were captured using this model.

Residential Real Estate Premiums

For the current study, Schmitz's 2006 estimates of the total statewide residential real estate premiums attributable to frontage on or proximity to golf courses were updated. Schmitz estimated per-community residential real estate premiums for golf course communities, applying the estimated per-community premium to the total estimated number of golf course communities in the state. The estimate was updated by calculating a premium proportional to the underlying value of the home versus a fixed value per house, and accounting for underlying real estate value fluctuations between 2004 and 2014 using data from the Case Schiller Home Price Index for Phoenix. Finally, the estimate was adjusted to account for changes in the number of golf course communities in the state since the previous study.

Golf Environmental Analysis

This final section of this study focuses on golf facility irrigation water use and conservation practices, relying on both primary and secondary data. Survey results were used to derive statewide estimates of water use, turfgrass management practices, and conservation activities. That information was supplemented with US Geological Survey (USGS) and Arizona Department of Water Resources (ADWR) data for a higher level picture of golf water use in Arizona.

Arizona Golf Facilities

The following section presents the results of the statewide golf facility survey by subject and covers the wide variety of activities that occur at golf facilities, including at the clubhouse (administration, restaurant, events), the golf course (golf play, course maintenance), and the pro shop (golf merchandise retail, lessons, and services). Information from all three facility roles and general facility characteristics are presented. Excluding response counts, figures presented are statewide estimates derived using survey response data according to the methods described in Appendix C.

Population and Distribution by Facility Characteristics

This section of the report provides an overview of the total population of golf facilities in Arizona and how survey responses by facility respondent role compare with the full golf facility population in the state as measured by different facility characteristics. To derive reliable estimates of statewide economic contributions, it's important that survey responses be representative of all facilities statewide in terms of their basic characteristics, such as location, year established, and facility type, among other measures.

There were a total of 359 responses to the online survey, 142 of which were from superintendents, 137 were general managers, and 80 were golf professionals (Table 1). Of those responses, not all responses provided useable data. For example, some respondents started the survey and stopped before answering any questions beyond initial facility characteristics. That considered, the useable response rate hovered around 40% for both superintendents and general managers, and 25% for golf professionals.

The distribution of survey responses by number of holes at the facility across all three facility roles shows that the response closely mirrors the overall distribution of facilities by number of holes, with the majority of respondents coming from 18-hole facilities (Table 2). The only discrepancy is in the number of 9-hole and 36-hole facilities, likely a result of multi-course facilities having different courses listed under different names in the full facility database, whereas in survey responses, respondents responded for their entire facilities.

Table 1. Survey Response Rates by Role of Survey Respondent

	Total Responses	Useable Responses	Total Response Rate	Useable Response Rate
Superintendent	142	121	45%	39%
General Manager	137	130	44%	42%
Golf Professional	80	79	26%	25%

Table 2. Survey Responses by Number of Holes at Golf Facility and Role of Survey Respondent

Holes	Super-intendent	General Manager	Golf Professional	Total Database
9	4.1%	3.1%	3.8%	11.8%
18	63.6%	72.3%	65.8%	67.4%
27	8.3%	3.8%	7.6%	7.0%
36	16.5%	16.2%	17.7%	12.5%
45	2.5%	1.5%	0.0%	0.6%
54	0.0%	0.8%	0.0%	0.3%
72	0.8%	0.8%	2.5%	0.0%
81	0.8%	0.0%	0.0%	0.0%
99	0.8%	0.0%	0.0%	0.0%
108	0.8%	1.5%	1.3%	0.3%
117	0.8%	0.0%	0.0%	0.0%
126	0.8%	0.0%	0.0%	0.0%
135	0.0%	0.0%	1.3%	0.0%

Table 3. Survey Responses by Type of Facility and Role of Survey Respondent

Type	Superintendent	General Manager	Golf Professional	Total Database
Public	48.8%	47.7%	50.6%	61.3%
Semi-private	24.0%	17.7%	17.7%	15.3%
Private	27.3%	33.1%	30.4%	23.3%
Other	0.0%	1.5%	1.3%	0.0%

Table 4. Survey Responses by Location of Facility and Role of Survey Respondent

Location	Super-intendent	General Manager	Golf Professional
A residential real estate development (including retirement communities or any housing development)	68.6%	66.2%	58.2%
A resort	13.2%	6.2%	12.7%
A park or recreation area (municipal, county, etc.)	5.0%	6.2%	5.1%
A military installation	1.7%	1.5%	1.3%
Tribal land	5.0%	1.5%	6.3%
Other	9.1%	10.0%	12.7%

Table 5. Survey Responses by Area of State and Role of Survey Respondent

Area	Super-intendent	General Manager	Golf Professional	Total Database
Phoenix and Central	69%	67%	66%	63%
Tucson and Southern	12%	16%	19%	17%
Northern	13%	12%	13%	12%
Western	5%	5%	3%	8%

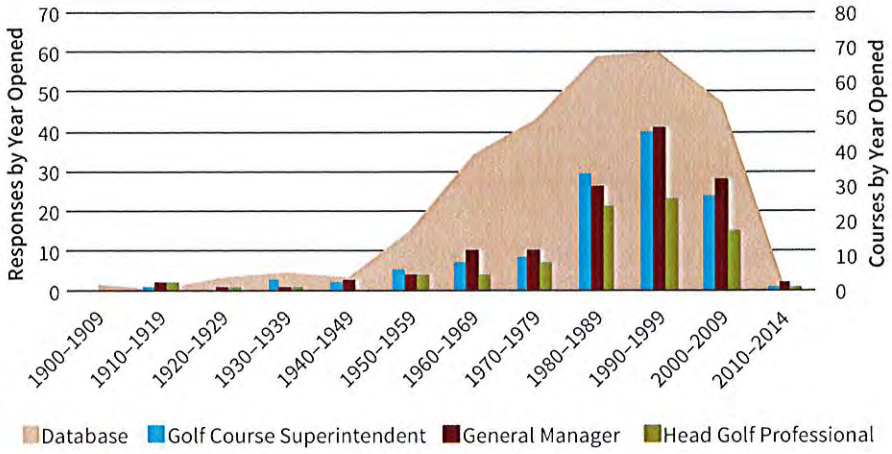
Similarly, response by role according to the type of golf facility reflects the general golf facility population with the highest proportion of facilities being public, followed by private, and then semi-private (Table 3).

Most facilities were located in either residential real estate developments or in resorts (Table 4). Columns may not sum to 100% as facilities can be located in more than one type of location, or in none. A comparison with the full course population is not provided because the location definitions in the database differ from those options provided in the survey.

Survey response by geographic location of the facility also closely resembles the full facility population in the state (Table 5). Roughly two-thirds of golf facilities are located in the metro Phoenix area, a little less than a fifth are located in Tucson and Southern Arizona, and the remaining fifth are located in Northern and Western Arizona.

In regard to the year that the golf facility was first established, survey responses closely resemble the pattern observed in the full database of facilities in the state. As can be seen in Figure 6, most facilities were first established between the mid-1980s and the mid-2000s. Since 2004, it is estimated that 17 golf facilities have closed and 19 new golf facilities have opened in Arizona, resulting in a net increase of 2 facilities.

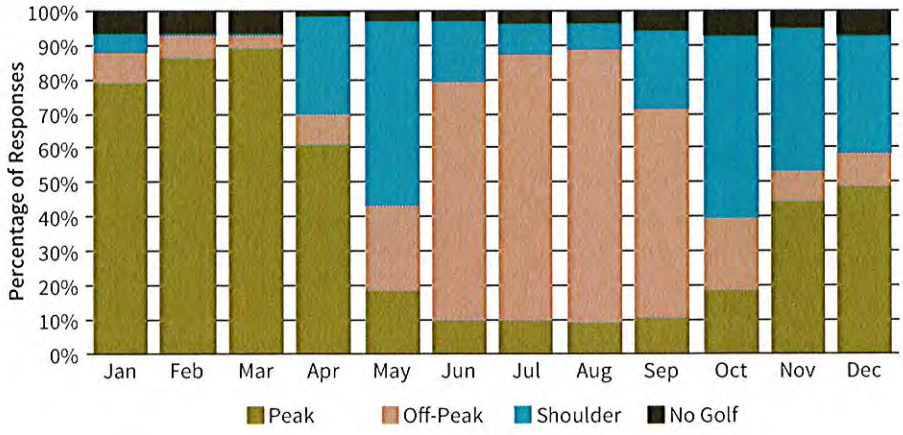
Figure 6. Date of Course Opening, Survey Responses vs. Full Database



Golf Play

An estimated 11,573,579 rounds of golf were played in Arizona in 2014.[2] Of total rounds, 7,678,120 were rounds played by members of private or semi-private facilities. 60.8% of total rounds were played during peak season, 19.6% during off-peak season, and 19.6% during shoulder seasons. Respondents were asked to indicate the months corresponding to peak season, off-peak season, shoulder seasons, and times when no golf was played at their facilities. A clear trend emerges, showing peak season beginning around November and peaking in March (Figure 7). Off-season begins in June and ends by October. Shoulder seasons were clustered around May and October. Months when no golf was played were spaced fairly consistently across

Figure 7. Percentage of Respondents Identifying a Given Month as Peak Season, Off-Peak Season, Shoulder Season, or No Golf Played



2 This estimate was corroborated using independent estimates of number of rounds played and matches closely with national estimates of average rounds per 18-hole equivalent course (Reitman, 2014) and numbers published by the Arizona Office of Tourism (2013).

Table 6. Percentage of Rounds Played in 2014 by Geographic Origin of Golfer

From Arizona (including seasonal residents)	US Visitors from Outside Arizona	International Visitors
67.7%	24.3%	8.0%

Source: Authors' estimates from survey

the year. Statewide seasonal trends are reflective of the concentration of courses in Phoenix and Central Arizona where winter months are peak season and summer months are off-peak season. For example, 79% of respondents consider August as off-peak season, 9% consider it peak season, 7% consider it as shoulder season, and 4% report no golf being played during the month of August.

Survey respondents were also asked to provide a breakdown of the geographic origin of golfers in terms of the percent of total play. Results indicate that roughly two-thirds of rounds are played by Arizona golfers, including seasonal residents. Roughly a quarter are played by visitors from other states, and the remainder (8%) are played by international visitors (Table 6).

Facility Revenues

Respondents were asked to provide a breakdown of facility revenue by category. This was done in one of two methods—either providing exact values by category or by providing a range of total revenues and a percentage breakdown by category. In the case that a range and percentages were provided, those percentages were applied to the range midpoint to yield estimated category values and were folded into the overall weighted average estimate. Total Arizona **golf facility revenues were** estimated to be **$1.1 billion in 2014** (Table 7).

While most golf facility revenue is generated by golf play, a significant amount of golf revenue is generated through golf pro shops. Golf pro shops are located at golf facilities, are staffed by golf professionals, and provide a variety of services and goods to golfers, including lessons, sales of hard and soft goods, and cart and equipment rental. About 88% of responding golf professionals indicated they are directly employed by the golf facility, 5% own and operate the pro shop on behalf of the facility, and another 5% work for a third-party management company. Of pro shop services provided, the most common responses (with 76 in all) were equipment and apparel sales and equip-

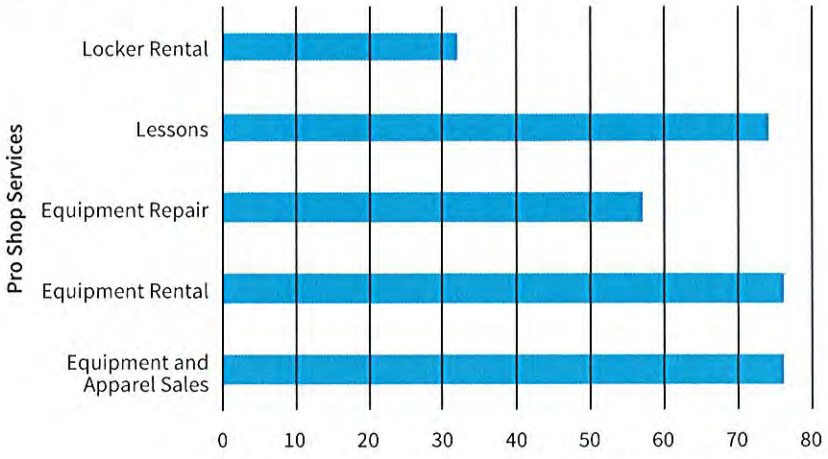
Table 7. Estimate of Statewide Golf Facility Revenues by Category, 2014

Revenue Category	Statewide Estimate
Initiation fees, annual membership fees and golf course dues	$386,325,091
Golf course green fees	$337,693,953
Restaurant, food and beverage services (golf facility only)	$201,517,614
Retail sales (golf shop, gift shop)	$86,805,260
Golf cart fees	$38,872,021
Flat fees paid for tournament events	$17,529,592
Driving range fees	$17,254,931
Flat fees for non-tournament private events (weddings, etc.)	$10,768,954
Private lessons given by facility personnel	$8,062,260
Flat fees for lessons given by third parties	$753,849
Other	$41,783,270
TOTAL	$1,147,366,795

Source: Authors' estimates from survey

ment rental. Based on survey responses, 17% of golf pro shop merchandise was purchased from in-state manufacturers of golf equipment and goods, such as Ping and AM&E. The second most common response was providing lessons (74 respondents). In fact, in 2014, golf professionals provided an estimated 150,545 half-hour lessons statewide, generating an estimated $8 million in revenue for Arizona golf facilities. Less common responses were equipment repair (57 respondents) and locker rental (32 respondents) (Figure 8).

Figure 8. Pro Shop Services Provided (Response Count)



Facility Expenses

Similar to revenues, respondents were asked to provide estimates of facility expenses by category, either providing exact values by category or by providing a total expense range and percentage breakdown by category (Table 8). Once again, in the case of a range and percentages, the percentages were applied to the midpoint of the expense range provided. Total Arizona **golf facility expenses were** estimated to be **$880 million in 2014** (Table 8). This implies that net of operating expenses, golf facilities retained an estimated $268 million in profits in 2014.

Table 8. Estimate of Statewide Golf Facility Expenses by Category, 2014

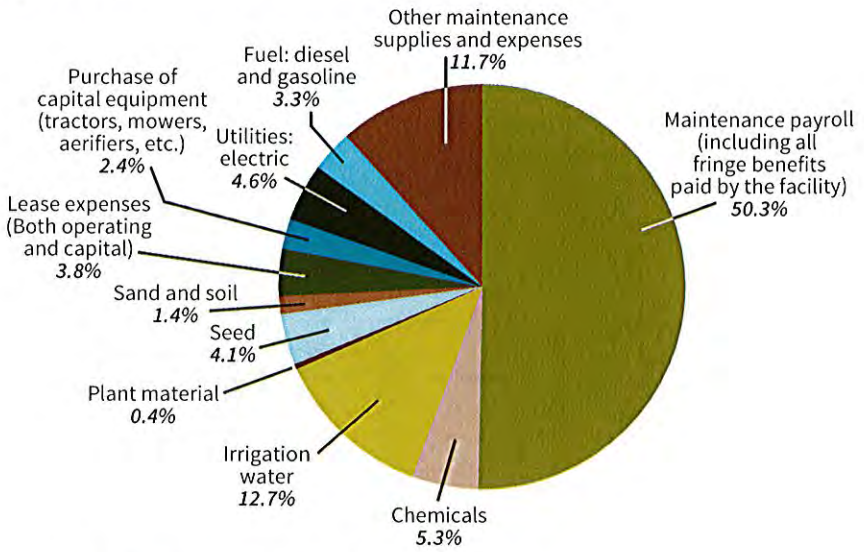
Expense Category	Statewide Estimate
Clubhouse payroll (employees whose work is based in the clubhouse or golf shop, including fringe benefits)	$200,165,974
Golf course maintenance payroll	$155,658,825
Utilities (water, electric, gas, etc.)	$95,841,042
Golf course maintenance supplies and services	$94,628,735
General administrative expenses (excluding utilities, payroll, and advertising)	$82,826,999
Cost of food and beverage	$76,510,958
Golf shop merchandise	$48,981,076
Lease expenses (both operating and capital)	$27,063,231
Payments on debt	$16,207,130
Advertising / Marketing / Promotion	$13,704,628
Facility insurance	$12,786,030
Cash contributions to charities	$1,196,438
Other expenses	$54,198,163
TOTAL	$879,769,229

Source: Authors' estimates from survey

As would be expected, payroll is the primary expense for golf facilities. Approximately 40% of total golf facility expenses are dedicated to clubhouse and golf course maintenance payroll (Table 8). Other major expenses are related to maintaining the courses.

Golf course maintenance staff works year round to maintain playable and attractive conditions on golf courses in Arizona. This requires a variety of inputs. Survey responses by superintendents suggest that spending on golf course maintenance is dominated by spending on payroll, which represented roughly half of all maintenance expenditures. The second highest expense category is irrigation water at roughly 13%, followed by chemicals (fertilizers, herbicides, and pesticides) at 5.3% of expenditures (Figure 9).

Figure 9. Golf Course Maintenance Expenditure Breakdown



Facility Employment

An estimated **18,700 full-time and part-time jobs** were directly linked to golf facilities in 2014 (Table 9). Total jobs were fairly evenly split between course maintenance, pro shop, and food and beverage service. Administrative and other jobs accounted for the smallest portion of total direct jobs.

Table 9. Estimate of Statewide Golf Facility Full- and Part-Time Employment, 2014

Employment	Full-Time	Part-Time	Total	% of Total
Course Maintenance	5,016	555	5,571	29.8%
Golf Shop	1,783	2,810	4,593	24.6%
Food and Beverage	2,324	3,115	5,439	29.1%
Administrative	835	207	1,042	5.6%
Other	1,076	973	2,050	11.0%
TOTAL	11,035	7,660	18,695	

Source: Authors' estimates from survey

Capital Investment and Renovations

Golf facility capital investment occurs on an annual basis in order to maintain buildings, equipment, furnishings, and golf courses. Survey respondents were asked to provide a breakdown of capital investments by category as well as the portion of the investment that was spent in-state. Based upon those responses, Arizona golf facilities spent an estimated $174 million on capital investment in 2014, of which **$101 million** was spent in Arizona (Table 10).

This investment in assets such as buildings, furnishings, and equipment adds to the overall value of assets owned by golf facilities, expanding the state and local tax base. As of December 2014, the assessed value of total owned assets of Arizona golf facilities was an estimated $3.7 billion.

Table 10. Estimate of Statewide Golf Facility Capital Investment and Amount Purchased In-State, 2014

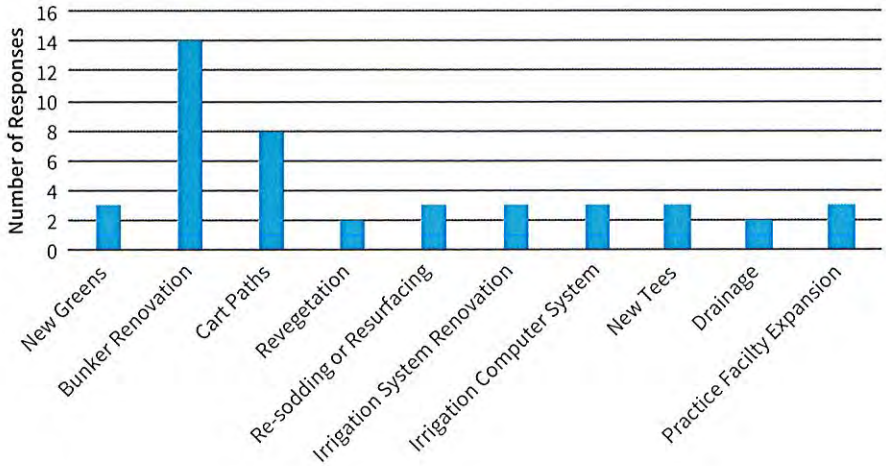
	Total	Purchased in AZ
Furniture	$17,812,758	$10,465,807
Equipment	$30,856,655	$18,273,506
Buildings	$36,511,494	$32,014,841
Other	$2,227,001	$2,102,121
Golf Course	$86,823,095	$37,791,883
TOTAL	$174,231,003	$100,648,158

Source: Authors' estimates from survey

In addition to annual capital investments in 2014, a review of publically available documents and news articles suggests that there were several Arizona golf facilities that underwent significant renovations in 2014. Facilities were reported as completing bunker renovations, adding tee boxes, relocating and resurfacing greens, replacing cart paths, re-landscaping desert areas, and even installing new irrigation systems. Survey respondents also reported course renovations, particularly bunker and cart path renovations (Figure 10).

In total, it is estimated that more than $20 million was spent on golf facility renovations in 2014. However, because capital investments and renovations can be funded through facility revenues, these values are not included in the total economic contribution analysis so as to avoid double-counting.

Figure 10. Golf Course Renovations by Type (Response Count), 2014



Charitable Contributions

Another major contribution of golf facilities is their generation of revenue for charitable causes. This occurs through a variety of channels. Many local golf tournaments serve as fundraisers for charitable organizations. According to survey results, roughly 32% of tournaments in 2014 in Arizona were hosted by a group whose purpose was to raise money for a charitable cause. Golf facilities also provide in-kind contribution of rounds of golf, lessons, and other goods and services for fundraising purposes. Finally, golf facilities make cash contributions to support charitable organizations. Statewide, an estimated $3.9 million in in-kind contributions were donated to charitable causes in 2014. Cash contributions totaled an estimated $1.2 million. Those cash contributions represent income for charitable organizations, supporting staff and programs.

Golf Tourism

This section presents an estimate of the money that is brought into the state from golf tourism. Two types of golf tourism are examined: travelers who visit Arizona for the primary purpose of playing golf, either recreationally, or in amateur tournaments, and travelers who visit Arizona to spectate at major professional tournaments. The calculations incorporate survey data on number of rounds played by visitor origin, information on golf traveler expenditures and visitation habits from a July 2016 study focusing on the Tucson and Phoenix/Scottsdale markets (Sports & Leisure Research Group, 2016), data from a 2012 study on the economic impact of the 2012 Waste Management Phoenix Open (Mokwa, et al, 2012), and reported attendance at major professional tournaments from local news media.

Golf Travelers

Out-of-State and Foreign Golfers

As presented in the previous section on golf play, roughly two-thirds of golf play in Arizona was by Arizona residents (Table 11). The remaining third was by out-of-state and foreign visitors. Based upon the estimated 11.6 million rounds played in 2014, 3.7 million rounds were played by out-of-state and foreign golfers. Those visitors create an impact on the state economy by bringing money from out of state and spending it on golf, lodging, restaurants, entertainment, and other local expenditures (Sports & Leisure Research Group, 2016).

Table 11. Geographic Origin of Golfers in Arizona, by Percentage of Total Play, 2014

Origin	Percentage of Total Play
From Arizona (including seasonal residents)	67.7%
US visitors from outside Arizona	24.3%
International visitors	8.0%

Reason for Visit

While many travelers play golf while on vacation or business, not all of those trips can be attributed to golf. For example, travelers may take a trip to a destination in order to visit friends or family or see specific attractions, and during the trip go golfing. In order to estimate tourist spending attributable to golf, it's necessary to have information on the proportion of golf travel for which the primary motivation for the trip was to play golf versus other activities. Recall that 3.7 million rounds of golf were played by out-of-state and foreign golfers. According to the 2016 Sports & Leisure Research Group study, the median number of annual golf trips taken per golf traveler is 6 trips per year, 3 for which golf was the primary motivation (either a golf vacation or travel to participate in an amateur golf tournament). Therefore, for the purposes of this study, 50% of travel rounds (1.9 million rounds) will be considered as attributable to golf. The same study reported an average of 6.1 rounds of golf played per trip. Dividing the estimated travel rounds attributable to golf by the average number of rounds per trip yields an estimate of 306,415 unique visits attributable to golf in 2014.

Expenditure Pattern

While some of the expenditures of out-of-state and foreign golfers are captured in the golf facility survey, such as rounds of golf played, revenues from greens fees and cart rentals, and total revenues from food and beverage purchases at the golf facility, other expenditures that happen outside the golf facility are not captured by the survey. These expenditures constitute an economic impact attributable to golf and therefore need to be estimated based upon golf traveler expenditure patterns. In the case of food and beverages purchased during travel, it can be assumed that some of these purchases occurred at the golf facility, while others occurred elsewhere. The estimated

spending on food and beverage is split half-and-half between the golf facility and outside the golf facility to exclude traveler spending at the golf facility that would be captured in survey data. Expenditures on airfare and fuel costs driving to the destination were assumed to have occurred out-of-state and therefore were excluded.

For this report, we use a golf traveler expenditure pattern from the 2016 Sports & Leisure Research Group report (Table 12).

Using the above spending pattern and the calculated number of trips attributable to golf tourists coming to play in Arizona, the estimated **direct economic impact of golf travel to the Arizona economy in 2014 was $539,465,000.**[3]

Table 12. Golf Traveler Spending Pattern

Item	Amount per Trip	Include or Exclude
Airfare	$439	Exclude
Car Rental	$209	Include
Fuel Cost	$153	Exclude
Golf	$448	Exclude
Lodging/accommodations	$609	Include
Local Transportation	$129	Include
Food/Dining/Beverage	$407	Include half
Entertainment/attractions	$255	Include
Shopping & other retails sales	$356	Include
Total	$3,004	$1,761

Source: 2016 Sports & Leisure Research Group "Visit Tucson" Report, Adjusted to 2014 Dollars

Professional Tournament Spectators

Tourists come to Arizona from outside the state not only to play golf, they also come to watch golf. Professional tournaments are a major attraction for out-of-state visitors. Furthermore, large professional tournaments require support staff and vendors who travel from out of state to support professional golfers, provide media coverage, and sell goods and services. Four of the largest professional tournaments in Arizona were included in this analysis (Table 13), estimating the number of unique out-of-town visitors based upon reported attendance in 2014.

Table 13. Major Professional Golf Tournaments in Arizona, 2014

Tournament	2014 Attendance	Host
Waste Management Phoenix Open	563,008	TPC Scottsdale
Charles Schwab Cup Championship	40,000	Desert Mountain
Accenture Match Play	40,000*	Dove Mountain
LPGA JTBC Founders Cup	56,250	Desert Ridge

** Attendance not known, estimated at 40,000.*
Sources: Arizona Republic (2016); Davis (2014a); Davis (2014b)

A 2012 economic impact study of the Waste Management Phoenix Open estimated that there were 67,320 unique visitors to the metropolitan Phoenix region attending the event. With a conservative assumption that half of those visitors were from out-of-state, this equates to unique out-of-state visitors representing 6.5% of reported attendance. That rate was applied to the attendance estimates for the other three tournaments (Table 13). In addition, the 2012 report provides an estimate of the number of support professionals attending the tournament, estimated at 234 individuals. That same number was used for the other three tournaments as well. All tournaments were either 4 or 5 days in length, therefore the average stay of 4.4 days used in the 2012 study was used for all 4 tournaments. Applying the spending pattern provided in the 2012 study, adjusted to 2014 dollars and excluding spending on airfare, an estimated **$58 million in out-of-state visitor direct spending** can be attributed to major professional golf tournaments.

Estimated Direct Impact of Golf Tourism in Arizona

Combining golf travelers and professional golf tournament spectators, the **total direct impact of golf tourism to Arizona's economy in 2014 was an estimated $598,300,000.**

3 Were all golf trips attributable to golf as the primary reason for the travel, the estimated direct contribution would be $1,078,931,000.

Golf-Related Businesses

Many businesses in the state supply and supplement the operations of golf facilities around Arizona. Supplying businesses are businesses whose goods and services would show up amongst itemized facility expenses, for example, businesses that supply golf course maintenance equipment, turfgrass irrigation consulting services, or wholesalers of golf apparel. Businesses that supplement golf course operations include standalone retailers, golf cart retailers, and other businesses that sell directly to consumers separate from golf facilities. As can be seen from survey results, most people golfing at Arizona golf facilities are in fact in-state Arizona residents, and therefore were it not for that in-state play, the demand for golf-related retail goods would be considerably less. For purposes of this analysis, supplying businesses are excluded because the economic activity they generate is captured by the golf facility operations survey data.

There are an estimated 155 establishments in the state that provide a variety of golf-related goods and services to consumers, such as golf carts, clothing and equipment, lessons, and equipment repair (Table 14). These are golf-related establishments that are not affiliated with an Arizona golf facility. A reported 59 of these establishments are golf equipment and supplies retailers, which includes establishments such as Vans Pro Shops and the PGA Tour Superstore. These golf retailers are a subset of sporting goods stores, which in 2012 had estimated sales of $767 million in Arizona (Census Industry Snapshot, 2012). With an estimated $94 million in sales in 2014, golf retail would therefore represent roughly 12% of sporting goods sales.[4] Another important category of golf retailers is golf cars and carts dealers, of which there are an estimated 62 establishments in Arizona. Table 14 provides a breakdown of businesses by industry that supplement golf facilities, the number of establishments in Arizona, and an estimate of their annual sales in 2014.

In total, the estimated **annual sales of golf-related business in Arizona was $270 million.** These sales constitute economic activity supported by golf facilities because the presence of golf facilities drives in-state demand for golf equipment and related services.

Not reflected in Table 14 are golf management companies. Arizona is home to two major golf management enterprises. Because these businesses are associated with the operations of golf facilities, their contribution to the state economy is reflected in the golf facility contribution analysis (in the next section of this report) through the share of golf facility profits that were assumed to be retained in-state.

Table 14. Estimate of Statewide Golf-Related Business Sales (Retailers and Service Providers), 2014

Segment	AZ Establishments	Sales Estimate
Golf Vacation Packages	4	$4,668,000
Golf Cars & Carts	62	$161,036,000
Golf Equipment and Supplies Retail	59	$94,134,000
Golf Equipment Repairing and Refinishing	1	$679,000
Golf Practice Ranges	6	$3,426,000
Golf Instruction	23	$6,217,000
Total	155	$270,160,000

Source: ReferenceUSA, MelissaData

4 Assuming sales in 2014 were similar to 2012, this matches closely with a 2013 estimate putting golf equipment at 12.5% of the sporting goods equipment market (Gale, 2016)..

Economic Contribution Analysis

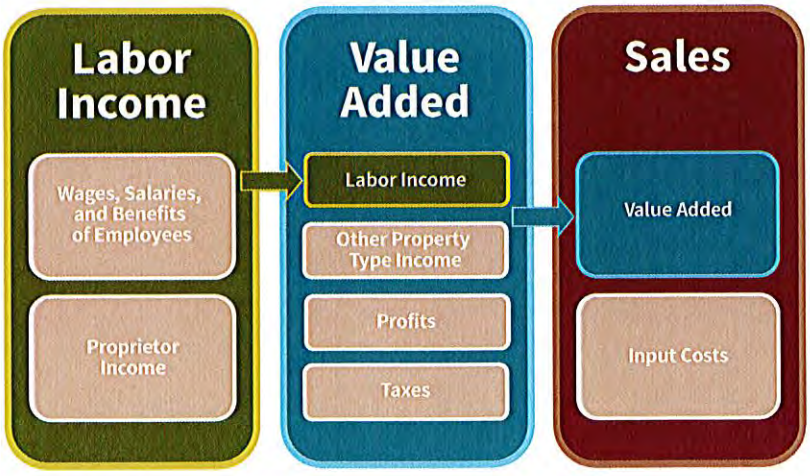
The following section presents economic contribution analyses for the three major components examined in this analysis—golf facility operations, golf tourism, and golf-related businesses. These contribution analyses utilize input-output modeling techniques and the IMPLAN 3.1 software, a regional economic model used to estimate the linkages between local industries.

The contribution of the golf industry to Arizona's economy goes beyond the revenues of golf facilities, golf tourist spending, and the sales of golf-related businesses, known as **direct effects**. Providing those goods and services requires inputs of other goods and services, including machinery, fertilizers, water, wholesale goods, and labor. Many of those goods and services are supplied by local businesses that themselves require inputs to operate and produce, and so on. Each additional round of transactions eventually dissipates as money leaks out of the state economy. These rounds of business-to-business transactions providing inputs to production are known as **indirect effects**. Another critical component of economic activity supported by the golf industry is the set of effects resulting from salaries and wages paid to people employed by the golf industry and its supplying industries. When these employees spend their paychecks on household expenses such as rent or mortgages, visits to the doctor, or groceries, more rounds of household-to-business transactions take place, known as **induced effects**. The total economic contribution of an industry is the sum of these three types of effects. For a detailed explanation of the methods used to calculate the economic contribution analysis, please see Appendices D and E.

A variety of economic metrics are used to describe the golf industry's contribution to the Arizona economy. These include sales (output), value added (GDP), labor income (employee compensation and proprietor income), jobs, and state and local taxes. It's important to note that many of these economic metrics are interconnected and, therefore, cannot be added together. Figure 11 demonstrates the relationship between sales, value added, and income.

Sales, or output, measures the total final value of goods and services produced by an industry. Sales is a gross measure of economic activity as it includes the value of economic activity generated in the industry (value added) as well as the costs of inputs. While sales is the easiest metric to understand,

Figure 11. Illustration of Relationship between Economic Metrics



the most precise metric to measure an industry's contribution to the Arizona economy is value added. Value added is the net incremental change in value from the last stage of production. It measures the additional gain in economic activity that can be attributed a particular industry. This metric is synonymous to the official measure of gross domestic product (GDP), the measure that is most often used to measure the size of an economy. Value added is comprised of the incomes paid to workers, the profits of the industry, and the taxes paid to the government (IMPLAN Group, LLC). Finally, labor income measures the total personal income supported by the industry. It includes the wages, salaries, and benefits of employees as well as the income of proprietors.

The following section of the report summarizes the results of the economic contribution analyses for golf facility operations, golf-tourism, and other golf-related businesses. Additionally, Figure 12 demonstrates the other industries in Arizona that are most affected through the multiplier effects generated by the golf industry.

Golf Facility Operations Economic Contribution Analysis

The economic contribution of golf facility operations was modeled in IMPLAN using the survey-derived estimates of statewide golf facility expenditures by category and profits using a technique known as analysis-by-parts. The model configuration assumes that 50% of profits remain in-state, based upon the fact that a number of large golf course operators and third-party management companies are based in Arizona, as well as accounting for the fact that some golf courses are owned and operated as Arizona-based businesses. The direct number of jobs supported was also a survey-derived estimate. Indirect and induced employment effects were estimated using IMPLAN.

Direct sales (output) of $1.1 billion through golf facility operations supported nearly 18,700 direct jobs earning over $623 million in labor income. That direct economic activity in turn generated indirect and induced multiplier effects. In total, the economic contribution of golf facility operations totals **$2.5 billion in sales, nearly 29,500 full- and part-time jobs earning $1.1 billion in labor income, and $1.4 billion in value added**, a measure equivalent to gross state product (GSP) (Table 15).

Table 15. Economic Contribution Summary for Golf Facility Operations, 2014

Impact Type	Employment	Labor Income	Value Added (GDP)	Sales
Direct Effect	18,695	$623,422,400	$623,422,400	$1,147,366,800
Indirect Effect	5,406	$259,012,500	$388,773,000	$670,173,800
Induced Effect	5,369	$234,940,600	$407,231,200	$715,332,400
Total Effect	29,470	$1,117,375,400	$1,419,426,600	$2,532,873,000

Table 16. Estimate of Statewide Golf Facility State and Local Taxes, 2014

State and Local Taxes	Amount
Property Tax	$22,862,400
Sales Tax	$38,764,700
Corporate Taxes & Dividends	$1,417,000
State Payroll Taxes	$6,810,100
Other Taxes & Fees	$2,603,500
Total State and Local Taxes	**$72,457,600**

Source: Authors' calculations using IMPLAN

In 2014, Arizona golf facilities operations directly contributed to local and state tax bases through property, sales, corporate income, payroll, and other local and state taxes and fees. An estimated **$72 million in state and local taxes**[5] were generated through Arizona golf facilities in 2014 (Table 16).

Golf Tourism Economic Impact Analysis

Similar to golf facility operations, golf tourism economic impacts were modeled in IMPLAN using a series of industry changes. The tourist

5 This estimate of state and local tax contributions was generated using IMPLAN 3.1. Golf facility revenue for 2014 was modeled using an industry change and modifying the industry change to reflect direct output, employment, employee compensation, and proprietor income estimates from survey responses.

spending pattern provided in previous sections was used to simulate economic activity in the hotel and restaurant industries and other industries where golf tourists would spend their moneys. Retail margins were applied to retail industries for purposes of calculating indirect and induced effects, while maintaining direct output as gross sales figures. Direct employment, labor income, and value added were calculated using IMPLAN.

As reported in previous sections, out-of-state tourist spending attributable to golf had an estimated direct sales impact of $598 million in 2014. Those sales, including indirect and induced multiplier effects, supported **$1.1 billion in sales, $576 million in value added, and nearly 10,500 jobs earning $343 million in labor income** (Table 17). Because this spending is by out-of-state visitors, it represents money coming into Arizona from outside the state. This represents exogenously demanded goods and services and therefore can be considered an economic impact (versus an economic contribution).

Table 17. Economic Contribution Summary for Golf Tourism, 2014

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	7,102	$192,571,900	$320,162,700	$598,300,200
Indirect Effect	1,478	$68,497,100	$113,541,400	$208,667,400
Induced Effect	1,875	$82,044,400	$142,217,800	$249,836,200
Total Effect	10,455	$343,113,500	$575,921,800	$1,056,803,800

Top industries impacted by golf tourism include hotels and motels ($199 million total sales impact), restaurants ($88 million total sales impact), and car rental ($68 million total sales impact), closely mirroring the tourist spending pattern (Figure 12). Hotel and motel sales supported by golf tourism support an estimated 1,960 full- and part-time jobs in that industry. Golf tourism directly generated an estimated $32 million in state and local sales tax revenues.

Figure 12. Top 10 Industries Impacted by Component of Economic Contribution Analysis

Golf-Related Businesses Contribution Analysis

Estimates of sales from golf-related businesses were modeled in IMPLAN as a series of industry changes according to their corresponding IMPLAN industries (Appendix E). Direct employment effects were estimated using IMPLAN, as were indirect and induced effects. Retail margins were applied to all retail industries in order to calculate indirect and induced effects, while the direct effects were measured as gross sales. This can be observed in the results (Table 18) in the relatively small indirect effects across employment, labor income, value added, and sales.

Table 18. Economic Contribution Summary for Golf-Related Businesses, 2014

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	1,216	$39,179,000	$58,615,800	$270,160,000
Indirect Effect	217	$9,622,600	$16,726,800	$30,233,100
Induced Effect	350	$15,332,900	$26,578,200	$46,689,600
Total Effect	1,784	$64,134,400	$101,920,800	$347,082,800

In total, including multiplier effects, golf-related business direct sales of $270 million supported a total of **$347 million in sales, $102 million in value added, $64 million in labor income, and nearly 1,800 full- and part-time jobs.**

Similar to the case of golf facilities, the top industries affected by spending at golf-related businesses includes those same golf-related businesses (direct effects), but also industries affected when individuals employed by supporting industries go out and spend their incomes on household expenditures such as rent or mortgage or medical care (Figure 12). Golf-related businesses generated an estimated $6.5 million in direct sales tax revenues for local and state governments.

Total Economic Contribution

The total contribution of the golf industry in 2014, including golf facility operations, golf tourism, and golf-related businesses, totaled **$3.9 billion in direct, indirect, and induced sales** (Table 19). Nearly **42,000 jobs** were supported, both directly and through multiplier effects, earning **$1.5 billion in labor income**. The golf industry contributed **$2.1 billion to gross state product** (value added) through direct and multiplier effects.

Table 19. Economic Contribution Summary, Total, 2014

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	27,013	$855,173,300	$1,002,200,900	$2,015,827,000
Indirect Effect	7,101	$337,132,100	$519,041,200	$909,074,400
Induced Effect	7,595	$332,317,900	$576,027,200	$1,011,858,200
Total Effect	41,708	$1,524,623,300	$2,097,269,200	$3,936,759,600

Residential Real Estate Premiums

The hedonic price method is a common method used in real estate and environmental economics to estimate the economic value of attributes of a neighborhood such as quality of schools, environmental goods (such as proximity to parks or open space), or environmental risks (such as proximity to Superfund sites). The basic idea behind this approach is that a house can be characterized as a bundle of attributes. Some of these attributes are specific to the house (square footage, lot size, whether it has a swimming pool), while others are attributes of the neighborhood where the house is located. Multivariate regression analysis is used to estimate the value of a home as a function of its various attributes. Several studies have included proximity to golf courses as one variable for analysis, either as a main factor of interest or simply as a control variable.

Such hedonic studies have consistently found that homes near golf courses receive price premiums. Table 20 provides a sample of such studies from different areas across the United States. Models either estimate how home values decline with distance from a golf course or create categorical variables to measure whether a home fronts on a golf course or is within some distance of a course.

Table 20. Selected Hedonic Study Estimates of Home Price Premiums for Proximity to Golf Courses

Study	Years	Market	Estimated Premium
Grudnitski (2003). Golf course communities: the effect of course type on housing prices. The Appraisal Journal.	1998–2001	Las Vegas, NV	Private course–12.5%; Semi-private course–6% Public course–5.7%
Do & Grudnitski (1995). Golf courses and residential house prices: An empirical examination. Journal of Real Estate Finance & Economics, Vol 10 No 3.	1990–1993	Rancho Bernardo, CA	7.6% adjacent to course
Grudnitski & Do (1997). Adjusting the value of houses located on a golf course. The Appraisal Journal, Vol 65 No 3.	1990–1993	Rancho Bernardo, CA	4.8% adjacent to course
Asabere & Huffman (1996). Negative and positive impacts of golf course proximity on home prices. The Appraisal Journal.	1992–1994	Mount Laurel, NJ	7–8% premium for frontage
Nicholls & Crompton (2007). The Impact of a Golf Course on Residential Property Values. Journal of Sport Management, Vol 21.	1997–2001	College Station, TX	Adjacent to course: Sales price–25.8% Assessed valuation–19.2%
Owusu-Edusei & Espey (2003). Does proximity to a golf course matter? Clemson University Working Paper, WP 012203.	1994–2001	Greenville, SC	Course-abutting houses sell for 27% more than those beyond 1,100 feet away, 15% more for houses between 300 and 1,100 feet away
Shultz & Schmitz (2009). Augmenting Housing Sales Data to Improve Hedonic Estimates of Golf Course Frontage. Journal of Real Estate Research, Vol 31 No 1.	2000–2006	Omaha, NE	For adjacent houses: Private non-equity: 28% Public: 15% Municipal: 9% Private-equity: 5%
Shin, Saginor & Van Zandt (2011). Evaluating Subdivision Characteristics on Single-Family Housing Value Using Hierarchical Linear Modeling. Journal of Real Estate Research, Vol 33 No 3.	2008	College Station, TX	16.25% (attached to golf course)

Turning to studies in Arizona, two from the Phoenix metropolitan area, Seo et al. (2014) and by Larson and Perrings (2013), found strong statistical evidence that – controlling for other factors—housing prices declined with distance from golf courses. Larson and Perrings found robust results examining effects within individual Phoenix metro area school districts. They stated:

> "The consistency of the coefficient signs for vegetation abundance and **proximity to golf** and large parks highlight their importance across the entire metropolitan area." (p. 52)

> "Our findings confirm the importance of water-related environmental amenities in a desert environment. Vegetation abundance and **proximity to water-intensive land uses such as golf and lakes are all amenities, reflecting the influence of the hot desert climate on homeowner choice.**" (p. 54).[6]

In studies of the Tucson metropolitan area, Shultz and King (2001) and Bark et al. (2011) also found statistically significant premiums for proximity to golf courses. Shultz and King found housing values fell with distance from golf courses, with the effects being consistently stronger for private than for public courses. Bark et al. (2011) found statistically significant premiums for homes adjacent to golf courses, but no premiums for homes close to, but not adjacent to, courses.

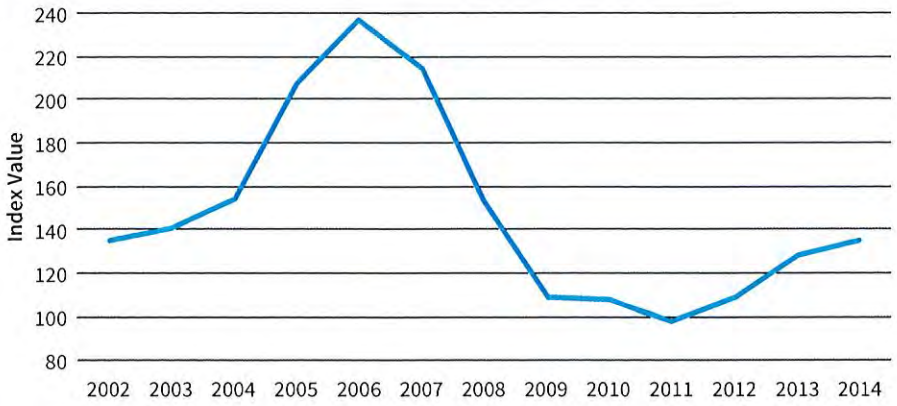
While hedonic studies have consistently found home price premiums for proximity to golf courses, these studies have, by their nature, focused on housing sub-markets of urban areas. Hedonic studies have encountered various estimation problems when extending their geographic scope too far. These problems often have to do with particulars of different sub-markets. For this reason, they are not amenable to developing statewide estimates of golf course premiums.

In contrast to a hedonic approach, Schmitz (2006) developed statewide estimates for the premium attributable to all homes ever built in golf course communities in Arizona. This was in turn based on an SRI International (2002) report that estimated that golf course communities on average had between 100 and 200 frontage lots and between 300 and 400 non-adjacent community lots. Home price premiums were reported to average $50,000 for frontage lots and $10,000 for non-adjacent lots. Schmitz (2006) assumed golf communities would—on average—have the midpoint number of each type of home: 150 frontage lots and 350 non-adjacent lots. The total premium per community was then estimated to be $11 million. Based on a survey conducted for the study, Schmitz (2006) estimated there were 187 residential golf courses in the state. Multiplying per-community premiums times the 187 courses, Schmitz estimated that the total premiums attributable to all homes built in golf course communities was $2,057,000,000.

For the current study, we update estimates of this total statewide premium in two ways. First, the hedonic home value literature has consistently estimated the golf amenity premium as proportional to the underlying value of a home. For example, a 10% golf course proximity premium would be $40,000 for a $400,000 home, but $100,000 for a million dollar home. Because of this, one would expect the golf course premium to change with baseline home values. The real estate market in Arizona has gone through

6 Emphasis by author.

Figure 13. Case Shiller Home Price Index for Phoenix, 2002–2014



Source: St. Louis Federal Reserve Bank and author's calculation. Index deflated using GDP deflator.

substantial fluctuations since Schmitz's original 2004 analysis. Second, the number of golf course communities has increased since 2004, although several have either not begun to be built out, while others have only been partially built out.

To account for real estate fluctuations and their effects on baseline home values, we turn to the Case Schiller Home Price Index (Figure 13). It turns out that, despite sharp fluctuations, the baseline prices of homes in the Phoenix metropolitan area are, in inflation-adjusted terms, almost identical to values in 2002, the time of the original SRI International report on golf course premiums. Figure 13 shows the Case Shiller Home Price Index for Phoenix homes adjusted for overall inflation using the GDP deflator. The index rose 76% from 2002 to 2006, then fell 59% from 2006 to 2011. The prices of Phoenix homes have recovered since 2011. Adjusted for inflation, the Case-Shiller index in 2014 was 99.9% of its 2002 level.

Second, according to survey results, 64.3% of facilities were reported as being associated with a residential real estate development. If this percentage is applied to the estimated total of 313 facilities in the database, this would yield an estimate of slightly more than 201 residential golf courses in the state. Many new residential facilities are only partially built out, however. Using Google Earth to inspect 19 new residential golf communities constructed since 2004, it was found that only two were fully built out, with ten having only a portion of homes constructed. By visual inspection it was estimated that the number of homes constructed was equivalent to about 5.4 communities of the size in the original Schmitz study. A half built-out community was assigned a value of 0.5 or a quarter built-out community a value of 0.25, for example. So, of the estimated 201.3 developments, 19 were subtracted, then 5.4 added back to account for partial building. This left a figure of 187.7—again, little changed from the 2004 estimate of Schmitz.

Based on minor adjustments for housing prices and total residential golf course community developments, it was estimated that the total real estate premium attributable to all Arizona homes built in residential golf communities was $11 million X 0.999 X 187.7 = $2,062,635,300, nearly $2.1 billion.

Water and Conservation Practices

The following section provides information on golf facility water use, water conservation practices, and turfgrass management practices used in Arizona. Additionally, it presents government data on golf water use in the state to supplement survey-based estimates.

Table 21. Estimated of Statewide Golf Facility Acreage, 2014

Estimated Golf Facility Acreage by Type	Acreage
Total acres of golf course(s)	45,270
Turfgrass acres maintained	31,883
Acres irrigated	34,430
Total acres of golf facility (incl. clubhouse, golf shop, golf courses, restaurants, etc.)	54,786

Acreage

In 2014, golf facilities used an estimated 55,000 acres of land in Arizona. Approximately 80% of facility land is dedicated to the golf course with the remainder of the land supporting clubhouses, pro shops, restaurants, parking and roads. Maintained turfgrass occupies just 70% of the land dedicated to the golf course. According to US Geological Survey (USGS) estimates, in 2010 there were 29,680 acres of turfgrass dedicated to golf in Arizona.

Irrigation Water Used

Based upon survey responses, golf facilities used an estimated 167,397 acre-feet (AF) of irrigation water in 2014 statewide. Respondents reported that on average 15.7% of golf irrigation water was Central Arizona Project (CAP) water, 1.9% was surface water, 38.5% was groundwater, 35.0% was reclaimed water, and 9.0% was from other water sources. This percentage for reclaimed water is somewhat higher than estimates from water resource agencies (see below).

According to the Arizona Department of Water Resources (ADWR), in 2014 golf facility water use in Active Management Areas[7] (AMAs) stood at 129,003 AF, with roughly 34,000 AF of this being effluent. While most golf facilities are located within AMAs, which encompass the state's major population centers, some facilities do fall outside the AMAs and are not reflected in that total. We therefore would expect that the statewide golf water use estimate to be higher than what is reported by the ADWR.

According to another source, the USGS, 130,116 AF of self-supplied freshwater was withdrawn for golf use in 2010. That same year, according to the USGS, 49,488 AF of reclaimed wastewater was used for golf course irrigation statewide in 2010. This suggests that in 2010 statewide golf water use was closer to 179,000 AF.

From another angle, turfgrass has a consumptive use[8] of roughly 4.38 AF per acre per year (Brown & Frisvold, 2016), which would indicate roughly 139,648 AF of consumptive use in 2014 based upon maintained tufgrass acreage estimates for 2014. Factoring in additional irrigation for landscape, water features, and any irrigation inefficiencies, a statewide estimate of 167,397 AF is in line with expectations.

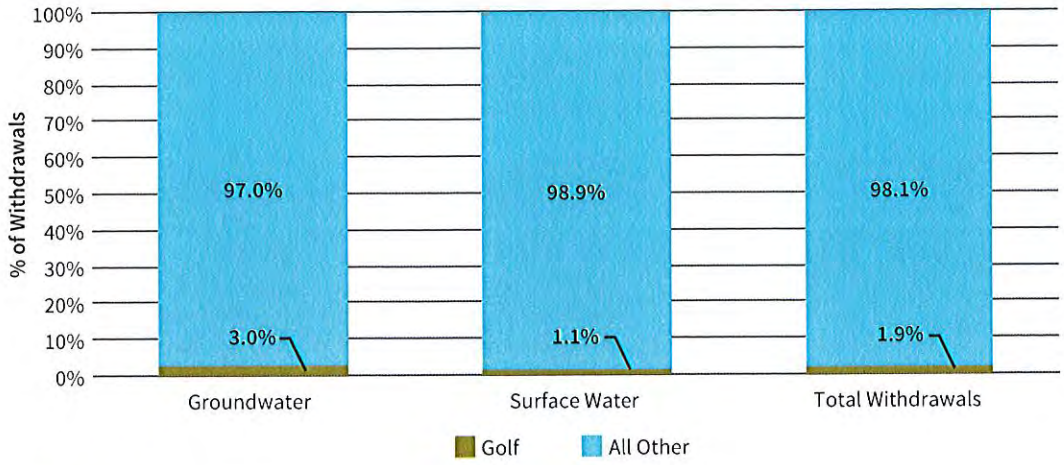
The following two sub-sections present golf irrigation water use data in Arizona from the US Geological Survey and the Arizona Department of Water Resources. This data supplements survey response data, providing a more nuanced look at golf irrigation water use statewide, regionally, by source of water used, and by year since 2004.

US Geological Survey

The US Geological Survey conducts a national survey of U.S. water use every five years, with the most recent conducted in 2010, with results published in

7 Active Management Areas (AMAs) are areas in Arizona where groundwater use is regulated and monitored according the Arizona Groundwater Code. There are five AMAs in Arizona: Phoenix, Tucson, Prescott, Pinal, and Santa Cruz. (ADWR, 2016)
8 Consumptive use is the water requirement of a crop or plant and includes losses through evapotranspiration and evaporation from soils.

Figure 14. Golf Freshwater Withdrawals Compared to Withdrawals for All Other Uses, Arizona 2010



Source: USGS, 2010

2014 (Maupin et al., 2014). The 2010 survey was the first to report data on water use by golf courses. The USGS reports data on freshwater withdrawals for golf course irrigation along with data for other withdrawals (e.g. for mining, residences, agriculture, etc.). In addition to reporting data for total withdrawals, USGS reports freshwater withdrawals from groundwater and surface water sources separately.

Data are available for 2010 for Arizona counties and the state as a whole (USGS, 2016). Freshwater withdrawals for irrigation by golf courses accounted for 1.9% of total freshwater withdrawals in Arizona in 2010. Focusing on the source of freshwater (groundwater or surface water), golf withdrawals accounted for 3.0% of total groundwater withdrawals and 1.1% of all surface water withdrawals in the state (Figure 14).

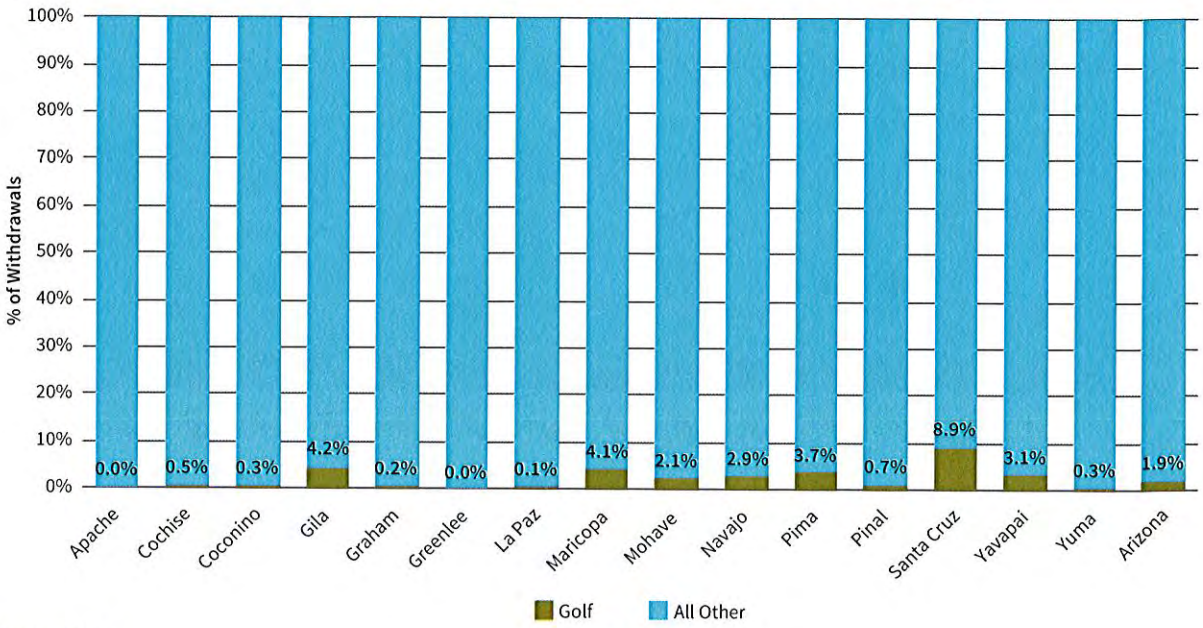
By county, golf freshwater withdrawals (including both groundwater and surface water) ranged from less than 1% of total freshwater withdrawals to 8.9% of total freshwater withdrawals (Table 22). However, only one county in Arizona (Santa Cruz County) has golf course irrigation freshwater withdrawals that accounts for more than 5% of total freshwater withdrawals. Figures 15 to 17 present data from Table 22 graphically.

Table 22. Freshwater Withdrawals for Golf Course Irrigation as a Percentage of Total County Withdrawals for All Uses, 2010

	Share of Total County Groundwater Withdrawals	Share of County Surface Water Withdrawals	Share of Total County Freshwater Withdrawals
Apache	0.0%	0.0%	0.0%
Cochise	0.5%	0.0%	0.5%
Coconino	0.5%	0.2%	0.3%
Gila	4.3%	0.0%	4.2%
Graham	0.4%	0.0%	0.2%
Greenlee	0.0%	0.0%	0.0%
La Paz	0.7%	0.0%	0.1%
Maricopa	4.4%	3.8%	4.1%
Mohave	3.8%	0.0%	2.1%
Navajo	3.2%	0.9%	2.9%
Pima	3.8%	3.0%	3.7%
Pinal	1.6%	0.3%	0.7%
Santa Cruz	8.9%	0.0%	8.9%
Yavapai	3.2%	2.5%	3.1%
Yuma	1.1%	0.2%	0.3%
Arizona	3.0%	1.1%	1.9%

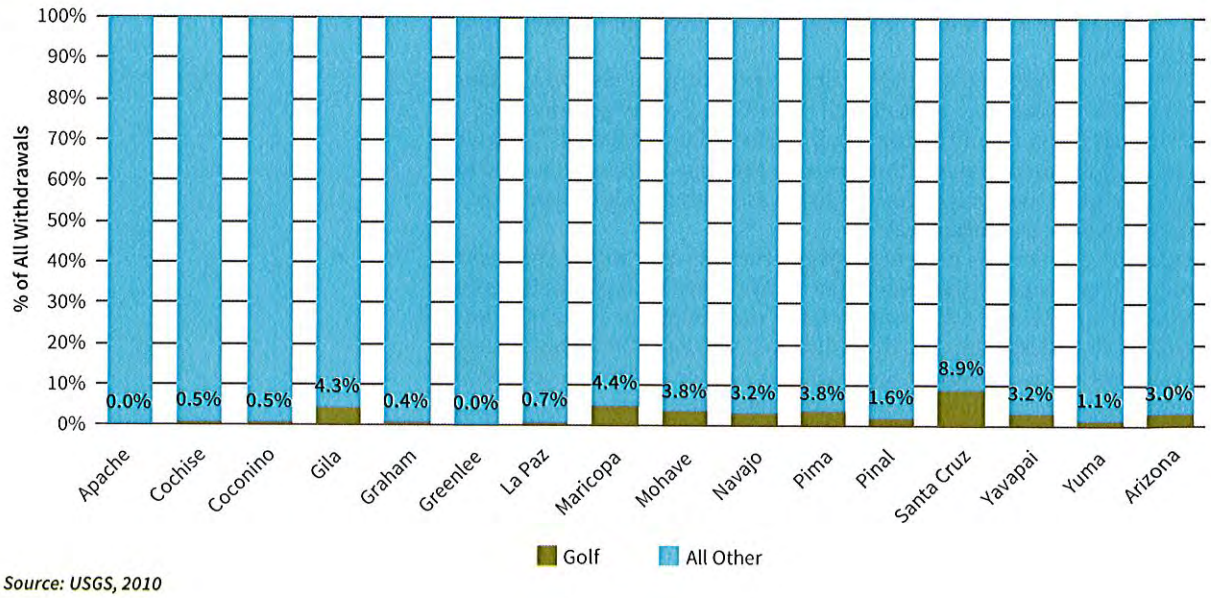
Source: USGS, 2010

Figure 15. Total Freshwater Withdrawals by County, Golf vs. All Other Withdrawals, Arizona 2010



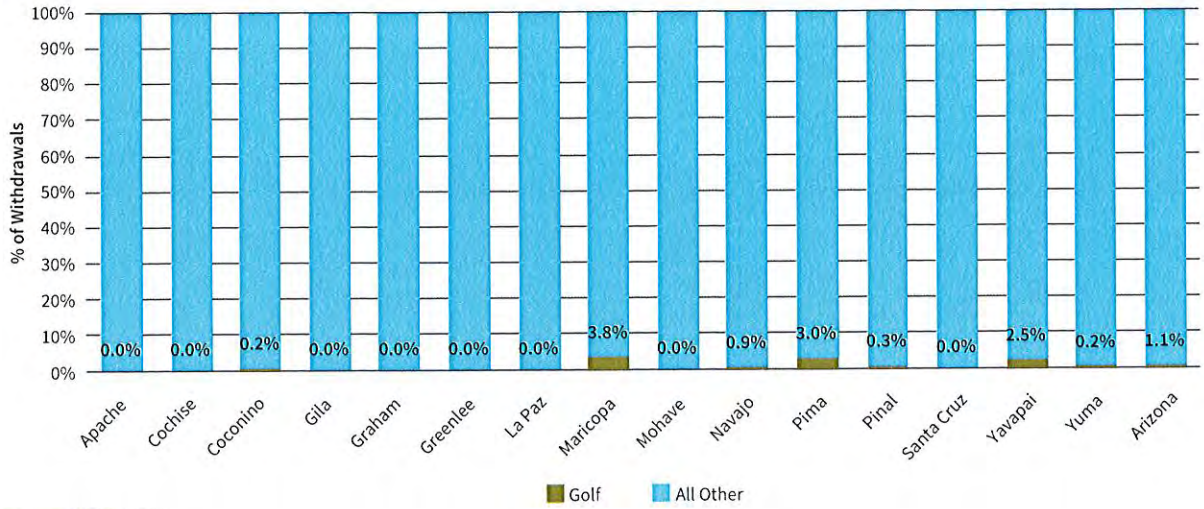
Source: USGS

Figure 16. Groundwater Withdrawals by County, Golf vs. All Other Withdrawals, Arizona 2010



Source: USGS, 2010

Figure 17. Total Surface Water Withdrawals by County, Golf vs All Other Uses, Arizona 2010



Source: USGS, 2010

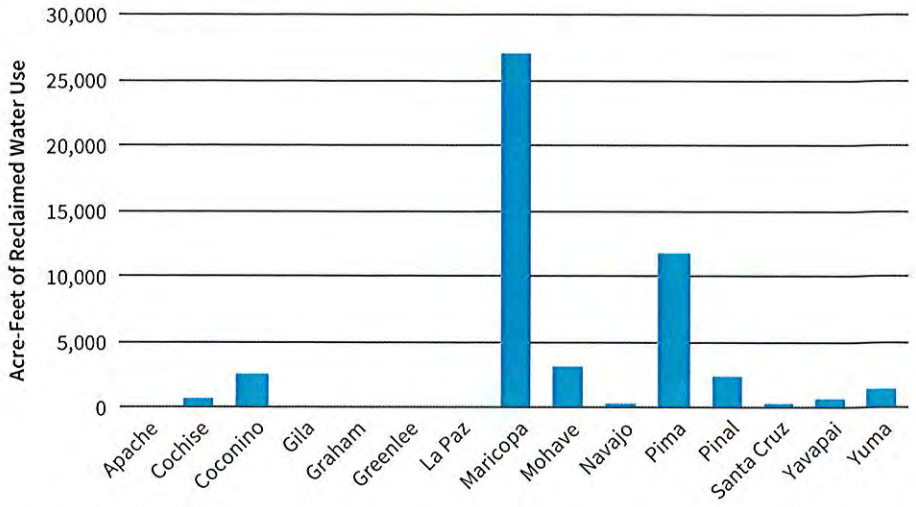
Figure 15 presents total freshwater withdrawals for golf by county, including both surface water and groundwater. In Santa Cruz County, golf irrigation withdrawals accounted for 8.9% of freshwater withdrawals. This is the only county that exceeds 5% of total country freshwater withdrawals. Golf course irrigation accounted for approximately 4% of freshwater withdrawals in Gila, Maricopa, and Pima Counties, 3% of freshwater withdrawals for Yavapai and Navajo Counties, 2% for Mohave County, and less than 1% for all other Arizona counties.

Turning to groundwater withdrawals in Figure 16, groundwater withdrawals for golf irrigation were 8.9% of total Santa Cruz County groundwater withdrawals (Table 22 and Figure 16). In Mohave, Pima, Maricopa, and Gila Counties, golf groundwater withdrawals ranged from 3.8% to 4.4% of county totals. In six counties, golf course irrigation accounted for less than 1% of county groundwater withdrawals.

Figure 17 presents the percentage of golf surface water withdrawals compared with total surface water withdrawals by county. Golf course irrigation accounted for 2.5% to 3.8% of surface water withdrawals in Yavapai, Pima, and Maricopa Counties (Table 22). According to USGS data, these three counties are the most reliant on surface water withdrawals for golf course irrigation. Elsewhere golf irrigation withdrawals were less than 1% of total surface water withdrawals.

The USGS also reports on golf course use of reclaimed wastewater for golf course irrigation. Statewide, 49,488 AF of reclaimed wastewater was used for golf course irrigation in 2010, accounting for 34% of total statewide reclaimed wastewater use for irrigation. Figure 18 presents golf course reclaimed wastewater use by county. According to the USGS, more than half of all golf course reclaimed water use takes place in Maricopa County, with more than 27,000 AF of reclaimed water used.

Figure 18. Golf Course Use of Reclaimed Wastewater by County, Arizona, 2010



Source: USGS, 2010

Table 23. Number of Golf Facilities by AMA in 2014

AMA	Golf Facilities
Phoenix AMA	183
Pinal AMA	14
Prescott AMA	6
Santa Cruz AMA	4
Tucson AMA	45
Total	**252**

Source: ADWR

Table 24. Number of Facilities Using Water Source by AMA, 2014

AMA	Ground-water	Surface Water	SPIL	CAP	Effluent
Phoenix AMA	112	51	33	57	66
Pinal AMA	7	0	0	2	5
Prescott AMA	2	0	0	0	4
Santa Cruz AMA	3	0	0	0	1
Tucson AMA	25	1	0	1	25
TOTAL	149	52	33	60	101

Source: ADWR

Arizona Department of Water Resources

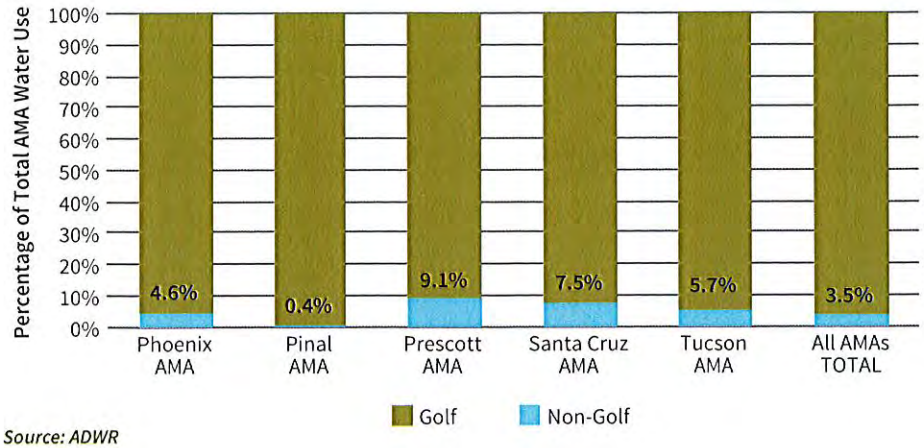
Active Management Areas (AMAs) are designated areas of the state that regulate the use of groundwater. As part of reporting requirements, golf course irrigation water use within AMAs is tracked by the Arizona Department of Water Resources (ADWR). Out of the state's 313 golf facilities, 252 (81%) are located in AMAs, and 183 of those are located in the Phoenix AMA (Table 23).

Golf courses within AMAs use a variety of water sources for irrigation, including groundwater, surface water, spillwater (defined in subsequent sections), Central Arizona Project (CAP) water (defined in subsequent sections), and effluent. Whereas some AMA golf courses rely on a variety of water sources, others rely heavily on a single source, such as effluent or groundwater, as is the case in the Prescott and Santa Cruz AMAs, respectively (Table 24).

In 2014, golf represented 3.5% of total AMA water use in Arizona (Figure 19). For the Phoenix AMA, golf represented 4.6% of total AMA water use and in the Tucson AMA, golf represented 5.7% of total AMA water use. The Prescott and Santa Cruz AMAs, smaller in terms of population, had higher percentages of total AMA water use represented by golf, at 9.1% and 7.5%, respectively. These AMAs also have relatively low concentrations of irrigated agriculture. Conversely, the Pinal AMA represents an area with a high concentration of irrigated agriculture and relatively few golf courses. Golf water use represented 0.4% of total AMA water use in the Pinal AMA in 2014.

Golf facility water use by AMA reflects the overall number of courses in each AMA by year. For example, in 2004 total golf water use is split fairly proportionally according to the share of 239 courses spread across the state's

Figure 19. Golf Water Use (Including Effluent) as a Percentage of Total AMA Water Use by AMA, 2014



Source: ADWR

AMAs. Similarly, water use data for 2014 reflects the share of 252 golf facilities located in all five AMAs.

Between 2004 and 2014 there was a net increase of 24,736 AF of annual golf facility water use across Arizona's AMAs (Figure 20). Most of the increase came from net increases in the Phoenix AMA (21,418 AF annually) and the Pinal AMA (2,348 AF annually). There was a net decrease in the Tucson AMA (1,869 AF), and a small increase in the Santa Cruz AMA. One potential reason for the net increase in water use from 2004 to 2014 is that the number of facilities in Arizona's AMAs has increased from 239 facilities to 252 facilities.

Figure 20. Golf Water Use by AMA, 2004–2015 (in Acre-Feet)

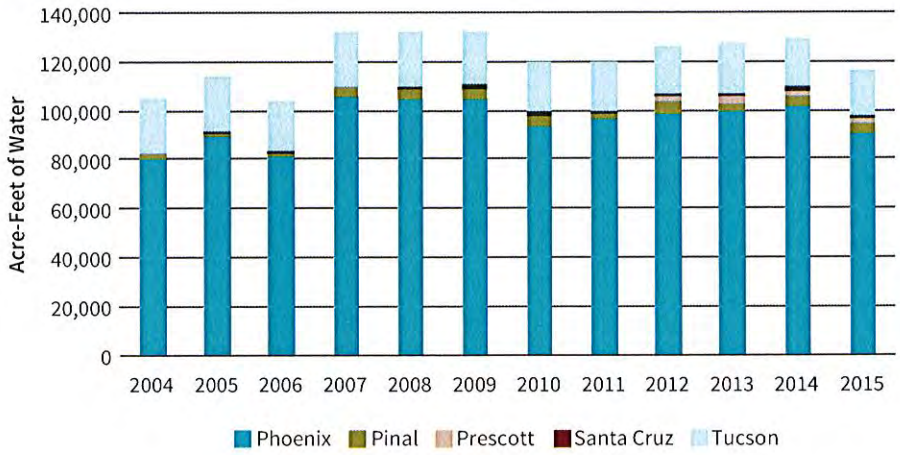
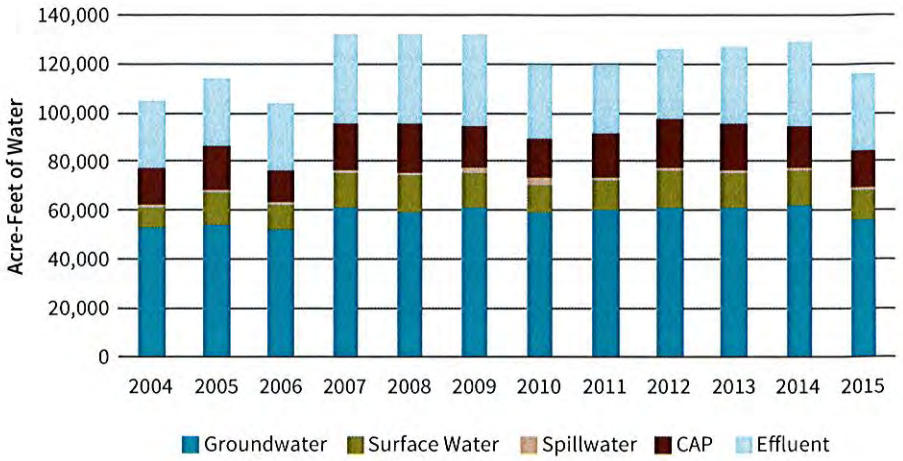


Figure 21. AMA Golf Water Use by Source, 2004–2015 (in Acre-Feet)



Total golf facility water use by source of water in Arizona's AMAs also remains relatively consistent across the years, while total use experiences some year-to-year fluctuation (Figure 21). Overall there was a net increase in water use from all sources between 2004 and 2014. In 2014, groundwater represented 48.1% of AMA golf water use, surface water, 10.9%, CAP, 14.6%, and effluent, 26.3%.

Figures 22 through 26 take a closer look at each source of water for golf use (groundwater, surface water, spillwater, CAP, and effluent) by AMA.

Most groundwater use occurs in the Phoenix AMA, followed by the Tucson AMA, also the two AMAs with the largest number of golf facilities (Figure 22).

Figure 22. Golf Groundwater Use by AMA, 2004–2015 (in Acre-Feet)

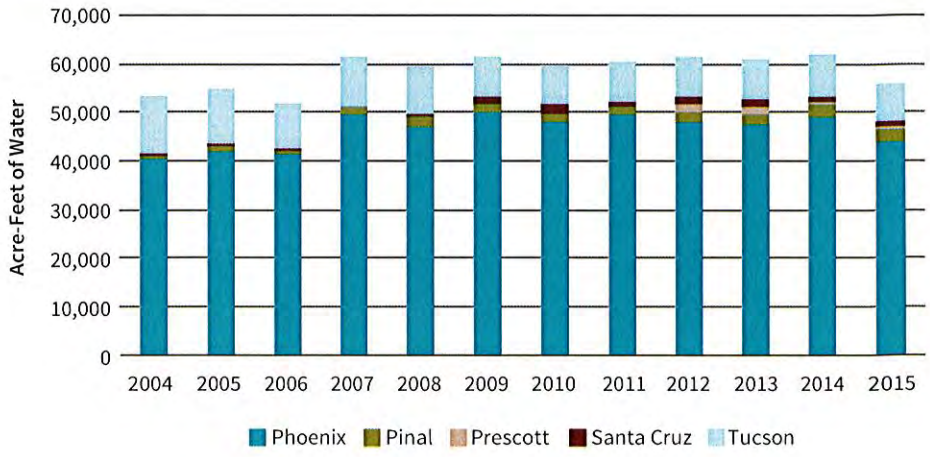
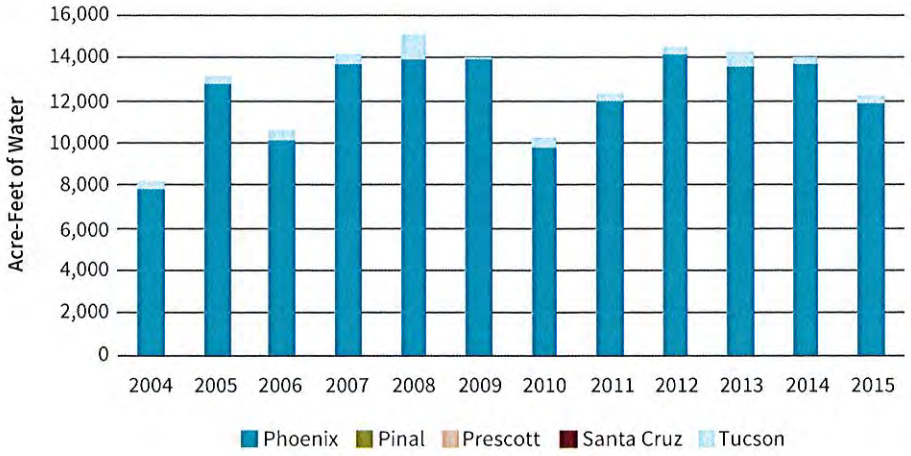


Figure 23. Golf Surface Water Use by AMA, 2004–2015 (in Acre-Feet)



Nearly all surface water use by golf occurs in the Phoenix AMA, reflecting Salt River Project water (Figure 23).

Spillwater represents a very small fraction of golf facility water use and occurs only in the Phoenix AMA. Spillwater is surface water released from storage (excluding Colorado River Water) to avoid spills that would otherwise occur when surface water inflows exceed facility capacities at storage, diversion, or distribution facilities (ADWR, 2016). Use of this water source peaked in 2010 at over 3,500 AF (Figure 24).

Figure 24. Golf Spillwater Water Use by AMA, 2004–2015 (in Acre-Feet)

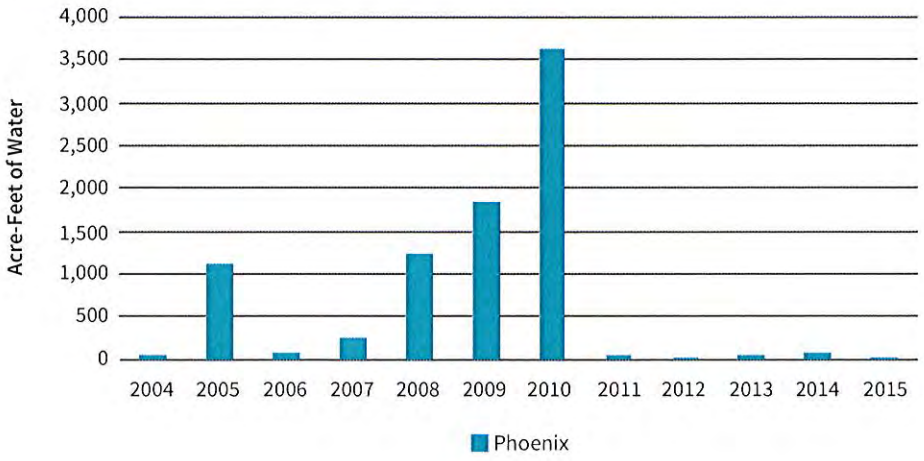
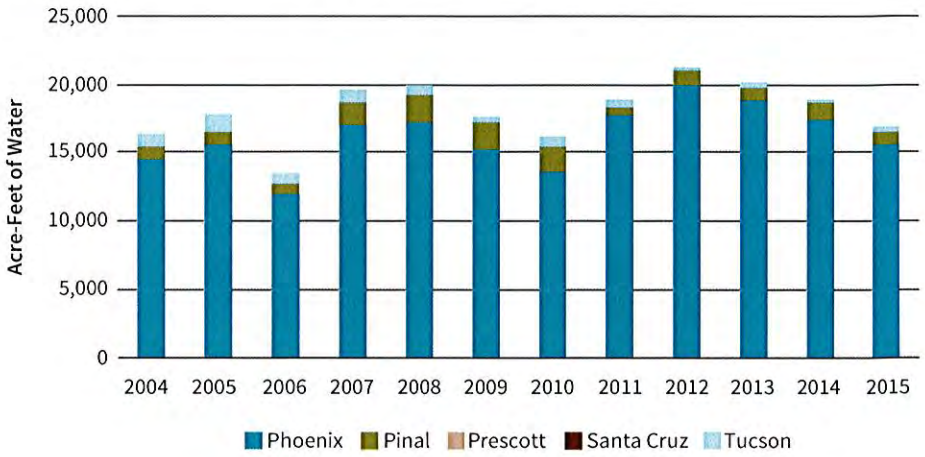


Figure 25. Golf CAP Water Use by AMA, 2004–2015 (in Acre-Feet)



Central Arizona Project (CAP) water use occurs predominantly in the Phoenix AMA, with some use in the Pinal and Tucson AMAs (Figure 25). This result is a function of the location of the physical infrastructure for water delivery (Prescott and Santa Cruz AMAs do not have access to CAP infrastructure), as well as the practice of CAP recharge in the Tucson AMA.

Use of effluent or reclaimed water is split primarily between the Phoenix and Tucson AMAs (Figure 26). Use of effluent in AMAs increased by 27% from 26,675 AF to 33,977 AF between 2004 and 2014.

Figure 26. Golf Effluent Use by AMA, 2004–2015 (in Acre-Feet)

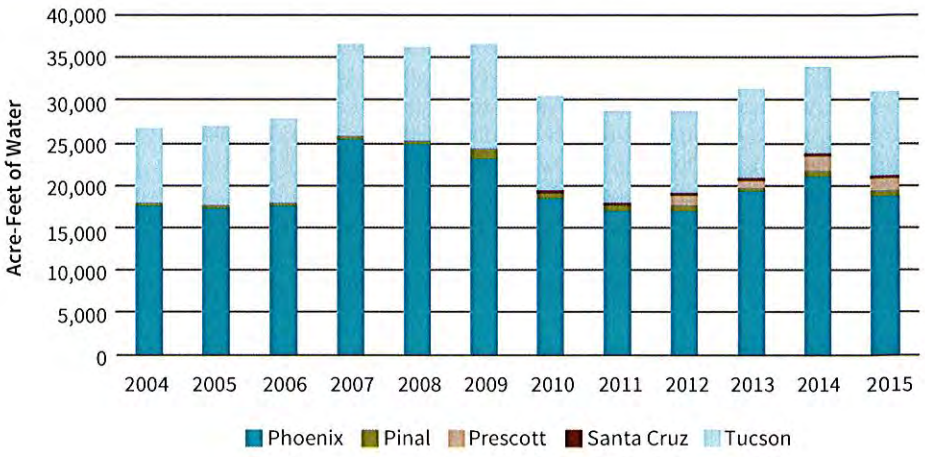


Figure 27. AMA Golf Water Use by Source, 2014

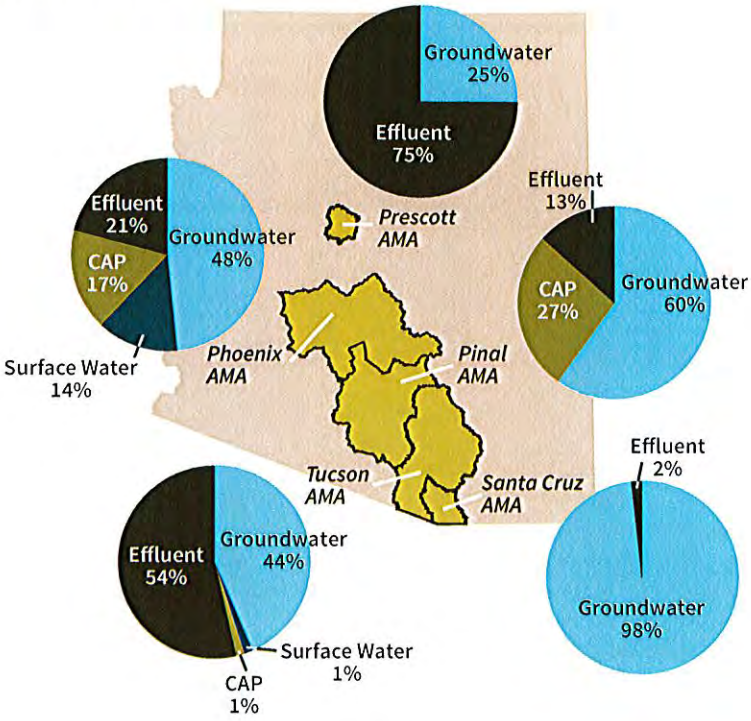


Figure 27 depicts the breakdown of AMA golf water use by water source throughout the state. The split varies significantly between AMAs, with some AMAs relying on a mix of sources while other AMAs depend almost exclusively on one source of water. In terms of total golf water use in the Phoenix AMA, roughly half is groundwater, and the remaining half is split between effluent, CAP, and surface water. The Pinal AMA relies heavily on groundwater, at 60% of golf water use. Approximately 27% of Pinal AMA water use is from the Central Arizona Project, and the remainder of use is met through effluent. In the Prescott AMA, golf facilities rely heavily on effluent, which represents 75% of golf water use in 2014. Groundwater made up the remaining 25%. In the Santa Cruz AMA, golf use consists almost exclusively of groundwater, with a small portion of use supplied through effluent. In the Tucson AMA, golf water use is dominated by effluent and groundwater, at 54% and 44% of use, respectively. CAP and surface water make up the remainder of use.

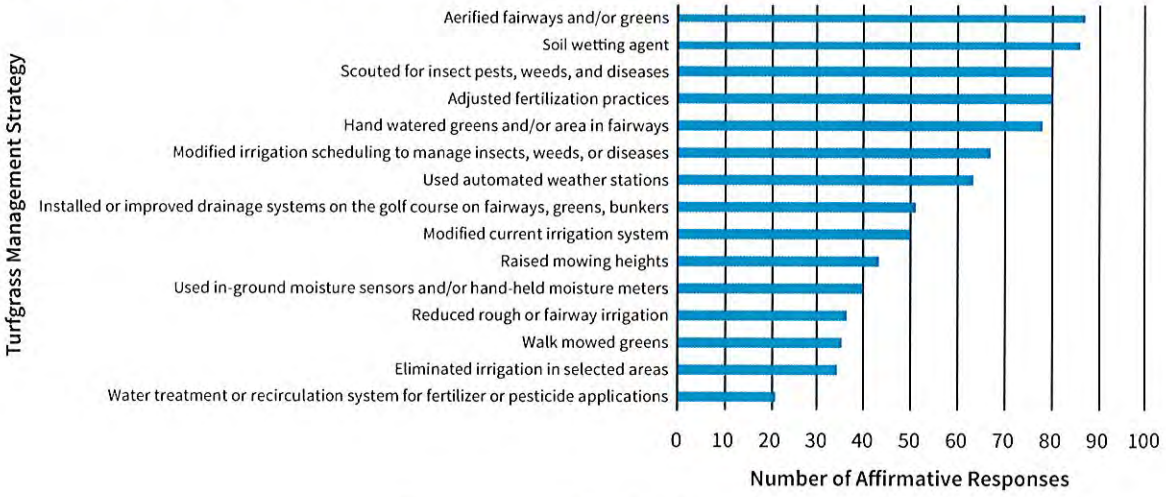
Irrigation Methods

Golf survey respondents provided a breakdown of irrigation methods used on Arizona golf courses (Table 25). On average, 93% of golf facility irrigation occurred using sprinklers and over 7% using drip irrigation. Turfgrass irrigation occurs almost exclusively using sprinklers (USGS, 2010), while drip irrigation is used for landscaping.

Table 25. Irrigation Method for Arizona Golf Facilities, 2014 (Survey Results)

Gravity	Sprinkler	Drip	Other
0.0%	92.8%	7.2%	0.1%

Figure 28. Use of Turfgrass Management Strategies (Response Count), 2014



Management Strategies

Golf course superintendents use a variety of turfgrass management strategies to monitor and maintain the health of turfgrass. These strategies are critical in maximizing the efficiency of use for water, chemicals, and other inputs. Survey respondents indicated whether they employed a series of turfgrass management practices at their facility (Figure 28). Some of the most common practices, according to survey results, include aerification of fairways and greens, using soil wetting agents (both associated with water use efficiency), and scouting for insect pests, weeds, and diseases. Other common practices associated with optimizing the application of irrigation include hand watering, modifying irrigation scheduling, and the use of moisture sensors.

Another common management strategy used to maintain turfgrass conditions is overseeding. Overseeding is the practice of applying cool-season turfgrass seed over existing warm-season turfgrass so that it germinates and grows-in as the existing turfgrass goes dormant. This is common in particular for turfgrass varieties such as Bermuda grass (GCSAA, 2016). Without overseeding, turfgrass in southern climates turns brown during winter months, losing much of its appeal to golfers, both aesthetically, as well as in terms of turf conditions. The process of overseeding requires significant amounts of water, and therefore many facilities pursue strategic reductions in overseeding to balance water conservation with economic viability of the course during peak season winter months. Survey respondents were asked to provide the average number of acres overseeded in 2009 and 2014. On average, there was a reduction from 89 acres overseeded in 2009 to 76 acres overseeded in 2014 (Figure 29).

Overseeding was most commonly practiced on fairways, followed by greens. Fewer respondents indicated overseeding rough areas of the course, and even fewer indicated overseeding wall-to-wall (Figure 30). The fewest respondents indicated painting or coloring greens instead of overseeding. These results indicate that most respondents are overseeding in areas that are higher priority for play, and less frequently overseeding in areas purely for aesthetics. Overseeding primarily in high-priority areas for play is associated with water conservation (both proactively as well as in response to water supply restrictions and high water prices), though it also can be a response to fewer golf course maintenance staff in the face of tightening budgets.

Figure 29. Average Acreage Overseeded in 2009 and 2014

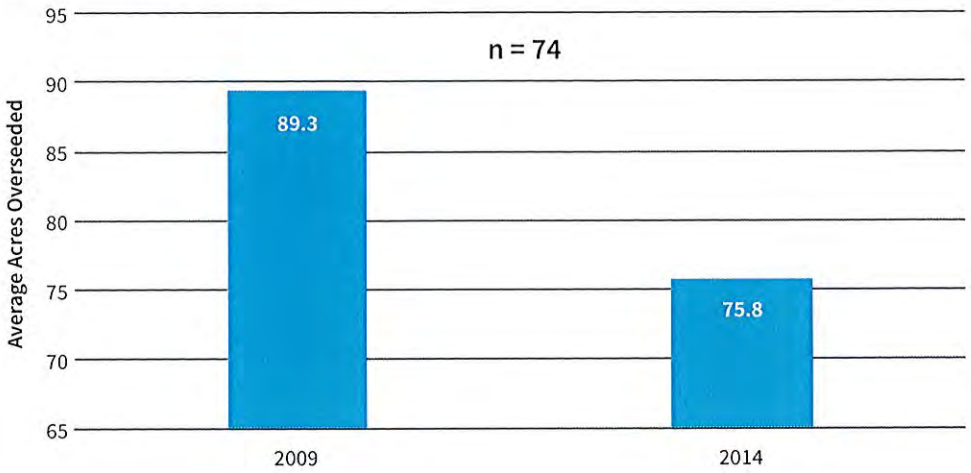
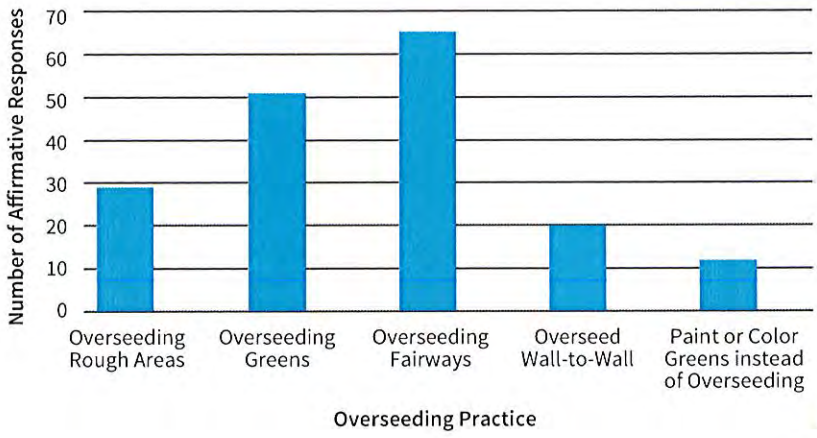


Figure 30. Overseeding Practices (Response Count)



Irrigation Audits

Irrigation audits are a strategy to reduce irrigation inefficiencies and losses, and reduce spending on irrigation water. Survey respondents were asked to indicate if their facility had performed an irrigation audit in the past 5 years, and if so, whether adjustments were made to the system and whether there were any resulting water savings. Just over a half of respondents indicated that their facility had performed an irrigation audit in the past five years (Figure 31). Of that half, 95% made adjustments to their irrigation systems, for an average irrigation water savings of 19.5 AF per year.

Figure 31. Irrigation Audit Performed in Past 5 Years and Resulting Water Savings, 2014

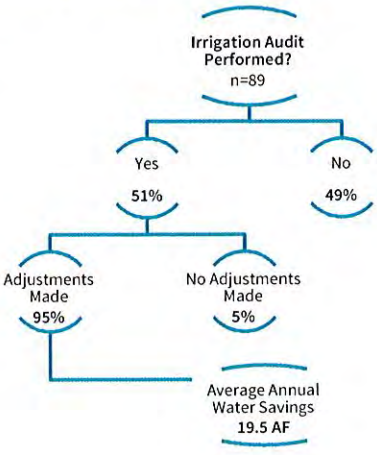
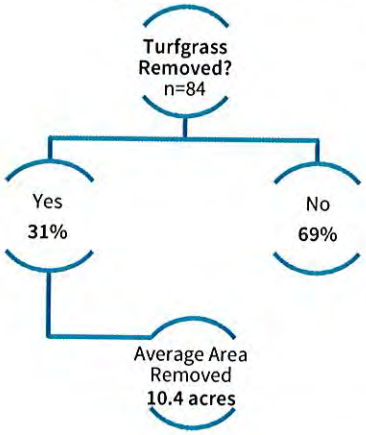


Figure 32. Turfgrass Acreage Removed Over Past 5 Years, 2014



Turfgrass Reductions

Another common water conservation practice is to selectively remove turfgrass where is does not affect the quality of golfers' experience, replacing it with other landscaping or surface coverings. Over the past 5 years (2009–2014), 31% of respondents removed an average of 10.4 acres of turfgrass from their facilities (Figure 32).

When turfgrass was removed, common replacements used included native vegetation and decomposed granite (Figure 33).

Efficiency Upgrade Investment Decision Making Process

The decision to invest in efficiency upgrades at a golf facility is an important one considering the tradeoff in costs associated with major investments and the benefits associated with upgrades. Golf facilities rely on a variety of sources of information and consider different variables in making their decision. The following provides a summary of respondents' key considerations and resources consulted in making efficiency upgrades. Survey respondents were asked to provide a free text entry response describing the motivations for efficiency upgrades and the information and resources drawn upon in making the decision.

By far, the most common consideration in investments in upgrades was the cost-benefit ratio or expected return on the investment (Figure 34). Second, was the ability to invest in the upgrade given the facility's budget. Less common responses included effects on course conditions and golfer experience, aesthetics, and environmental impact of the upgrades.

Golf facilities drew from a number of resources to make investment decisions regarding efficiency upgrades. The most common response was using an industry expert, consultant, agronomist, or architect to inform the decision-making process. The second most common responses were consulting with internal leadership, including ownership, management, boards of directors, or membership, and relying on staff monitoring and expertise. Other resources called upon included USGA consultant agronomists, USGA and GCSA industry association information resources, communication with other superintendents, and research and resources provided by Cooperative Extension (Figure 35).

Figure 33. Materials Used to Replace Turfgrass (Response Count)

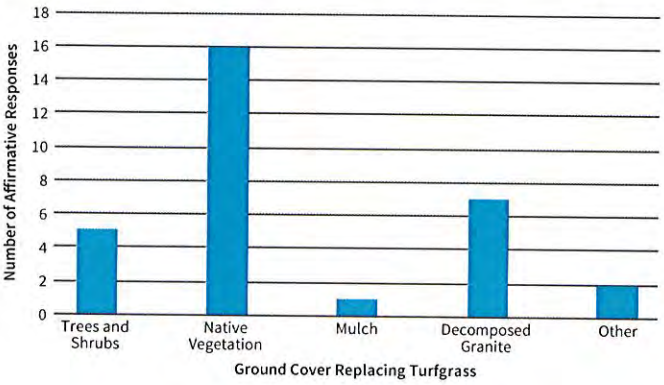


Figure 34. Factors Considered in Making Efficiency Upgrade Investment Decisions (Response Count)

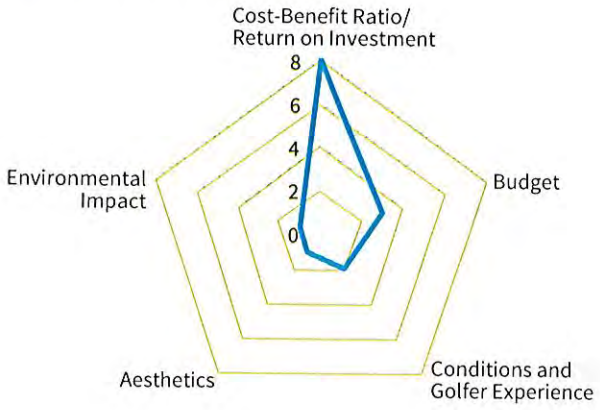
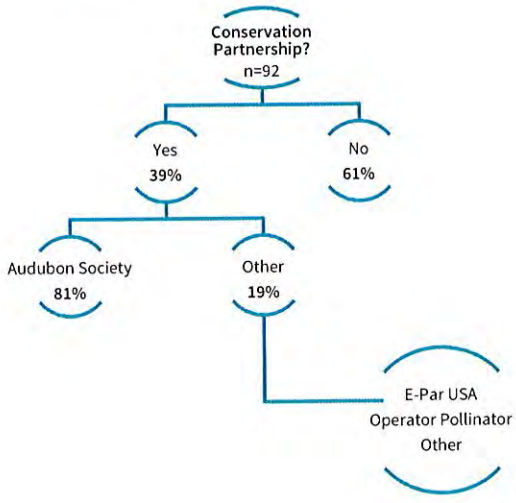


Figure 35. Resources Consulted in Making Efficiency Upgrade Investment Decisions (Response Count)

Environmental Management and Conservation Partnerships

Golf facilities commonly partner with conservation organizations to maximize wildlife habitat benefits provided by golf courses and to minimize any negative environmental impacts. The most common of these partnerships is the Audubon Cooperative Sanctuary Program for Golf through Audubon International which provides certification and education on environmental management strategies for golf courses (Audubon International, 2016). 39% of survey respondents indicated having a partnership with a conservation organization, of which 81% indicated they partner with Audubon International (Figure 36). The remaining 19% included a variety of other organizations, the most commonly cited being E-Par USA, though other responses included Operation Pollinator, adherence to municipal landscape policies, and GCSA and USGA membership. E-Par USA is a private company that provides environmental management systems and best practices resources to golf facilities in the interest of achieving greater environmental sustainability (E-Par USA, 2016).

Figure 36. Facilities' Partnerships with Conservation Organizations



Summary and Conclusions

This report presents an analysis of the golf industry's contribution to Arizona's economy and its influence on the environment including water use, conservation practices, as well as recent trends in both measures. Arizona's golf industry had a total estimated economic contribution of $3.9 billion in sales (output) to the state economy in 2014. This includes the direct, indirect, and induced effects of golf course operations ($2.5 billion), golf tourism ($1.1 billion), and golf-related businesses ($347 million).

Golf facility operations had a direct contribution of $1.1 billion in sales to the state economy. 18,700 full- and part-time jobs were directly supported by golf facility operations, earning more than $623 million in wages, salaries, and business income. Including multiplier effects, the total contribution was $2.5 billion in sales, $1.4 billion in value added (gross state product), and approximately 29,500 full- and part-time jobs. An estimated 11.6 million rounds of golf were played in Arizona in 2014.

Arizona's golf courses attract visitors from around the country and globe to play golf and spectate at professional tournaments. About one-third of rounds played in Arizona are by visitors from out-of-state, bringing in an estimated $598 million in tourist spending. In total, golf tourism's impact to the state economy was an estimated $1.1 billion in sales and approximately 10,500 jobs in 2014.

Finally, golf-related businesses provide equipment, apparel, and other goods and services to in-state golfers, who constituted roughly two-thirds of rounds played in 2014. These businesses represented an estimated $270 million in annual sales, primarily in retail industries, and nearly 1,200 jobs. Including multiplier effects, the total contribution of golf-related businesses was $347 million in sales and nearly 1,800 jobs.

Other effects of the golf industry are not best measured using regional economic contribution analysis. These effects include the influence of golf courses on residential real estate values and natural resource use and conservation. The study provides an update to a 2004 estimate of residential real estate premiums attributable to frontage on and proximity to golf courses. Accounting for changes in the real estate market and new construction since 2004, residential real estate premiums associated with all homes ever built in golf course communities in Arizona was estimated to be nearly $2.1 billion.

Finally, the study provides a snapshot of golf water use and conservation and management practices at Arizona golf facilities, drawing upon survey results and government water use data. According to survey results, Arizona golf facilities, statewide, used an estimated 167,397 AF of irrigation water in 2014, occupying a total of 45,000 acres for the golf courses, of which 32,000 acres was turfgrass. Survey estimates suggest that 35% of golf water use was effluent in 2014. According to USGS data for 2010, 130,116 AF of self-supplied freshwater was used to irrigate golf courses, accounting for 1.9% of Arizona's total freshwater (groundwater and surface water) withdrawals. Golf irrigation accounted for 3% of state groundwater withdrawals and 1.1% of state surface water withdrawals in 2010. An additional 49,488 AF of reclaimed wastewater was used for golf course irrigation in 2010, accounting for 28% of golf's total statewide water use. AMAs encompass most major urban areas of the state and roughly 80% of golf facilities statewide. Golf course irrigation represented 3.5% of total AMA water use in Arizona in 2014, according to the ADWR. In 2014, groundwater represented 48.1% of AMA golf water use, surface water, 10.9%, CAP, 14.6%, and effluent, 26.3%. Whereas some AMAs rely on a varied mix of water sources, others rely heavily on one or two sources,

such as effluent or groundwater. Between 2004 and 2014 the ADWR reported a net increase of 24,736 AF of golf facility water use in Arizona's AMAs, with all types of water use increasing. During that time, the number of facilities in Arizona's AMAs also increased, from 239 facilities to 252 facilities. Use of effluent in AMAs was 33,977 AF in 2014, increasing by 27% (from 26,675 AF) since 2004.

Conservation efforts at golf facilities aim to balance the use of natural resources with the economic viability of the courses. Arizona golf facilities employ a variety of water conservation strategies on their golf courses, invest in efficiency upgrades by consulting with industry experts and other resources in their decision-making process, and commonly partner with conservation organizations to institute best practices for wildlife management and promoting sustainability. 51% of responding facilities reported performing irrigation audits for their golf course irrigation systems in the previous 5 years, 95% of which made adjustments to their irrigation systems, for an average irrigation water savings of 19.5 AF of water per facility per year. 31% of facilities reported having removed turfgrass in the past 5 years. Another 39% reported having a partnership with conservation organizations, most commonly with Audubon International.

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Glossary and Acronyms

ADWR—Arizona Department of Water Resources

AF—Acre-Foot: a measure of water equivalent to the amount of water needed to cover an acre one foot deep with water

AMA—Active Management Area: Designated areas in Arizona with heavy reliance on groundwater that are subject to regulation according to Arizona's Groundwater Code (ADWR, 2016)

CAP—Central Arizona Project

CMAA—Club Managers Association of America

GCSA—Golf Course Superintendents Association

GDP—Gross Domestic Product

GSP—Gross State Product

IMPLAN—IMpacts for PLANning: Regional input-output model developed by IMPLAN Group, premier software and data package used for regional economic impact and contribution analysis

NAICS Code—North American Industry Classification System code: 2 to 6 digit codes used for purposes of classifying business entities by their primary industry in government statistics (US Census Bureau, 2016)

NGF—National Golf Foundation

PGA—Professional Golf Association

SIC Code—Standard Industry Classification Code: Industry classification codes later replaced by NAICS codes

SRP—Salt River Project

USGA—United States Golf Association

USGS—United States Geological Survey

Appendices

Appendix A: Survey Instrument

Arizona Golf Facility Survey

The following survey presents a series of questions regarding golf facility operations in Arizona in calendar year 2014. This is a one-time online survey which takes approximately 20 minutes to complete. Questions are tailored to your role(s) at the facility and the information you provide will be used in aggregate form to help us understand the economic contribution of the golf industry to the state of Arizona. This survey is distributed to the following three individuals at each golf course facility in Arizona (for definitions of roles, please hover cursor over each title):

- **General Manager / Director of Club Operations**
  Questions cover golf facility operations, including revenues and expenses, capital investment and construction, employment, and golf play
- **Golf Course Superintendent / Director of Agronomy**
  Questions cover maintenance expenditures, golf course renovations, golf course water use and irrigation, turfgrass management practices, and conservation practices
- **Head Golf Professional / Director of Golf**
  Questions cover golf shop revenues and expenses, golf tournaments, golf lessons, and charitable giving

It may be helpful to have 2014 financial information relevant to your role at the facility on hand in answering some of the questions.

Your participation in this survey is voluntary and if at any time you wish to stop, you are free to do so. All survey answers are anonymous.

Thank you for your participation!

**** GENERAL FACILITY INFORMATION ****

The following section includes general questions about the golf facility. If the golf facility includes multiple golf courses, please respond for the entire golf facility.

Number of golf courses at this golf facility:

	0	1	2	3	4	5	6	7	8	9	10	I prefer not to respond
Number of 9-hole courses	○	○	○	○	○	○	○	○	○	○	○	○
Number of 18-hole courses	○	○	○	○	○	○	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○	○	○	○	○	○	○

Type of golf facility:

- ○ Public
- ○ Semi-private
- ○ Private
- ○ I prefer not to respond
- ○ Other (please specify): _____

The golf facility is located within: (please select all that apply)

- ☐ A residential real estate development (including retirement communities or any housing development)
- ☐ A resort
- ☐ A park or recreation area (municipal, county, etc.)
- ☐ A military installation
- ☐ Tribal land
- ☐ None of the above
- ☐ I prefer not to respond
- ☐ Other (please specify): _____

Is your golf facility managed by a third-party management company?

- ○ Yes
- ○ No

In which Arizona county is your facility located?

- ○ Apache
- ○ Cochise
- ○ Coconino
- ○ Gila
- ○ Graham
- ○ Greenlee
- ○ La Paz
- ○ Maricopa
- ○ Mohave
- ○ Navajo
- ○ Pima
- ○ Pinal
- ○ Santa Cruz
- ○ Yavapai
- ○ Yuma
- ○ I prefer not to respond

Year that the golf facility first opened for operation: _____

- ○ I do not know
- ○ I prefer not to respond

If the golf facility opened in 2014, how many months was it operational during that year?

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ 11
- ○ 12

Did your golf facility construct a new golf course or any new holes in 2014? *This question refers only to NEW construction, and does NOT include renovation of EXISTING courses or holes.*

- ○ Yes
- ○ No
- ○ I prefer not to respond

Please indicate your role(s) at the golf facility. If you serve multiple roles at the golf facility (for example, you serve as both the general manager and superintendent), please select all that apply.

- ☐ General Manager / Director of Club Operations
- ☐ Golf Course Superintendent / Director of Agronomy
- ☐ Head Golf Professional / Director of Golf

For golf facilities and/or golf courses that opened for operation in 2014 or 2015, please provide estimates of all construction costs incurred in calendar year 2014:

Total construction costs _____
Golf course _____
Clubhouse _____
All Other _____

Total golf course construction costs in 2014: _____

****THESE QUESTIONS ARE FOR THE HEAD GOLF PROFESSIONAL / DIRECTOR OF GOLF****

Please answer questions with regards to the golf shop you manage and/or own

Please indicate the nature of your employment relationship with the golf facility

- ○ I am directly employed by the golf facility
- ○ I own and operate the golf shop
- ○ Other (please specify) _____

Including yourself, how many individuals are employed at the golf shop?

Full-time _____
Part-time _____

Please indicate which of the following goods and services your golf shop provides:

- ❑ Equipment and apparel sales
- ❑ Equipment rental
- ❑ Equipment repair
- ❑ Lessons
- ❑ Locker rental

The following section asks questions about revenues and expenses for the golf shop

It may be helpful to have 2014 financial records for the golf shop available in filling out this section of the survey. Approximate values are acceptable.

Please estimate the breakdown of revenues for the golf shop, either as dollar values or percentages. Please complete only one column.

	Dollar Value ($)	Percent of Total Revenue (%)
Hard goods		
Soft goods		
Equipment rental (clubs, cart, locker, bag storage, etc.)		
Other (ex. Equipment repair, books, videos, etc.)		

Please estimate the number of paid half hour lessons given by golf facility personnel in 2014:

_____

Please estimate the breakdown of expenses for the golf shop, either as dollar values or percentages. Please complete only one column.

	Expenses ($)	Percent of Total Expense (%)
Hard goods		
Soft goods		
Equipment rental (clubs, cart, locker, bag storage, etc.)		
Other (ex. Equipment repair, books, videos, etc.)		

In regards to total golf shop expenditures on hard and soft good merchandise, what is the percentage purchased from Arizona suppliers (ex: Ping, AM&E)? An approximate percentage is acceptable. _____

The next section relates to tournament events held at your golf facility

Did your golf facility hold any tournament events in 2014?

- ○ Yes
- ○ No

Number of golf tournaments of any size that were hosted at your golf facility in 2014:

Total number of tournaments _____
During the peak season _____
During the off-peak season _____
During the shoulder season(s) _____

Please estimate the revenues generated through tournaments in 2014:

Revenues generated for facility through PROFESSIONAL tournaments _____
Revenues generated for facility through ALL OTHER tournaments _____

Please estimate the total number of spectators attending professional tournament event(s) in 2014, if applicable: _____

Percentage of tournaments held in 2014 hosted by a group whose purpose was to raise money for a charitable cause: _____

Please estimate charitable contributions made by the golf facility in 2014:

Estimated revenue (cash contributions) generated for charities _____
Estimated monetary value of in-kind contributions to charities (free golf rounds, free lessons, etc.) _____

****THE FOLLOWING QUESTIONS ARE FOR THE GENERAL MANAGER / DIRECTOR OF CLUB OPERATIONS****

If the golf facility includes multiple golf courses, please respond for the entire golf facility (all golf courses, clubhouse, golf shop, etc.)

The following questions are regarding golf play in 2014

Please indicate the months corresponding to the following seasons in 2014:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peak season	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Off-peak season	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Shoulder season #1 (if applicable)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Shoulder season #2 (if applicable)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Months when no golf was played in 2014 (if applicable)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

Please estimate the number of 18-hole rounds played at your golf facility in 2014. Please count 9-hole or twilight rounds as one-half.

Total rounds _____
Paid rounds _____
Member rounds _____

Please estimate the percentage breakdown of paid rounds by season, if applicable:

____ Peak season paid rounds
____ Off-peak season paid rounds
____ Shoulder season(s) paid rounds

Please estimate the geographic origin of golfers that played in 2014 (% of total play):

____ From Arizona (including seasonal residents)
____ US visitors from outside Arizona
____ International visitors

The following questions are regarding revenues and expenses at the golf facility. It may be helpful to have 2014 financial records available in filling out this section of the survey. Approximate values are acceptable.

Total gross revenues and sales in 2014 from golf play, membership fees, driving range, golf shop, gift shop, food and beverage, private lessons, tournaments, and non-tournament private events (select appropriate range):

- ❍ < $250,000
- ❍ -$250,001 -$500,000
- ❍ $500,001-$750,000
- ❍ $750,001-$1,000,000
- ❍ $1,000,001-$1,250,000
- ❍ $1,250,001-$1,500,000
- ❍ $1,500,001-$1,750,000
- ❍ $1,750,001-$2,000,000
- ❍ $2,000,001-$2,250,000
- ❍ $2,250,001-$2,500,000
- ❍ $2,500,001-$2,750,000
- ❍ $2,750,001-$3,000,000
- ❍ $3,000,001-$3,250,000
- ❍ $3,250,001-$3,500,000
- ❍ $3,500,001-$3,750,000
- ❍ $3,750,001-$4,000,000
- ❍ $4,000,001-$4,250,000
- ❍ $4,250,001-$4,500,000
- ❍ $4,500,001-$4,750,000
- ❍ $4,750,001-$5,000,000
- ❍ $5,000,001-$5,250,000
- ❍ $5,250,001-$5,500,000
- ❍ $5,500,001-$5,750,000
- ❍ $5,750,001-$6,000,000
- ❍ $6,000,001-$6,250,000
- ❍ $6,250,001-$6,500,000
- ❍ $6,500,001-$6,750,000
- ❍ $6,750,001-$7,000,000
- ❍ $7,000,001-$7,250,000
- ❍ $7,250,001-$7,500,000
- ❍ $7,500,001-$7,750,000
- ❍ $7,750,001-$8,000,000
- ❍ $8,000,001-$8,250,000
- ❍ $8,250,001-$8,500,000
- ❍ $8,500,001-$8,750,000
- ❍ $8,750,001-$9,000,000
- ❍ $9,000,001-$9,250,000
- ❍ $9,250,001-$9,500,000
- ❍ $9,500,001-$9,750,000
- ❍ $9,750,001-$10,000,000
- ❍ > $10,000,000
- ❍ I prefer not to respond

Please estimate the breakdown of gross revenues by season:

____ Peak season
____ Off-peak season
____ Shoulder season(s)

Please estimate the dollar value or percent breakdown of total gross revenues and sales obtained from each of the following business activities in 2014 for the entire golf facility. Please complete only one column:

	Dollar Value ($)	Percent of Total (%)
Golf course green fees		
Golf cart fees		
Initiation fees, annual membership fees and golf course dues		
Driving range fees		
Private lessons given by facility personnel		
Retail sales (golf shop, gift shop)		
Restaurant, food and beverage services (golf facility only)		
Flat fees for lessons given by third parties		
Flat fees paid for tournament events		
Flat fees for non-tournament private events (weddings,		

etc.)		
Other		

Total costs of operation in 2014 for all business activities related to the golf course and golf facility only, excluding taxes (select appropriate range):

- ❍ < $250,000
- ❍ $250,001–$500,000
- ❍ $500,001–$750,000
- ❍ $750,001–$1,000,000
- ❍ $1,000,001–$1,250,000
- ❍ $1,250,001–$1,500,000
- ❍ $1,500,001–$1,750,000
- ❍ $1,750,001–$2,000,000
- ❍ $2,000,001–$2,250,000
- ❍ $2,250,001–$2,500,000
- ❍ $2,500,001–$2,750,000
- ❍ $2,750,001–$3,000,000
- ❍ $3,000,001–$3,250,000
- ❍ $3,250,001–$3,500,000
- ❍ $3,500,001–$3,750,000
- ❍ $3,750,001–$4,000,000
- ❍ $4,000,001–$4,250,000
- ❍ $4,250,001–$4,500,000
- ❍ $4,500,001–$4,750,000
- ❍ $4,750,001–$5,000,000
- ❍ $5,000,001–$5,250,000
- ❍ $5,250,001–$5,500,000
- ❍ $5,500,001–$5,750,000
- ❍ $5,750,001–$6,000,000
- ❍ $6,000,001–$6,250,000
- ❍ $6,250,001–$6,500,000
- ❍ $6,500,001–$6,750,000
- ❍ $6,750,001–$7,000,000
- ❍ $7,000,001–$7,250,000
- ❍ $7,250,001–$7,500,000
- ❍ $7,500,001–$7,750,000
- ❍ $7,750,001–$8,000,000
- ❍ $8,000,001–$8,250,000
- ❍ $8,250,001–$8,500,000
- ❍ $8,500,001–$8,750,000
- ❍ $8,750,001–$9,000,000
- ❍ $9,000,001–$9,250,000
- ❍ $9,250,001–$9,500,000
- ❍ $9,500,001–$9,750,000
- ❍ $9,750,001–$10,000,000
- ❍ > $10,000,000
- ❍ I prefer not to respond

Please estimate the dollar value or percent breakdown of costs in 2014 for the entire golf facility, excluding taxes. Please complete only one column:

	Dollar Value ($)	Percent of Total (%)
Clubhouse payroll (employees whose work is based in the clubhouse or golf shop, including fringe benefits)		
Golf course maintenance payroll		
eneral administrative expenses (excluding utilities, payroll, and advertising)		
Cost of food and beverage		
Golf shop merchandise		
Advertising / Marketing / Promotion		
Utilities (water, electric, gas, etc.)		
Golf course maintenance supplies and services		
Facility insurance		

Lease expenses (both operating and capital)		
Payments on debt		
Cash contributions to charities		
Other expenses		

Average number of full-time and part-time staff employed at your golf facility during 2014 (excluding third-party independent contractors and lessees such as food & beverage, golf academy, golf instruction):

	Full-Time	Part-Time
Course maintenance		
Golf shop		
Food & beverage		
Administrative		
Other		

Total number of employees that you paid (for any amount of time) during 2014: _____

Please estimate the amount spent on capital expenditures and improvements during 2014 for the golf facility, as well as the percent of purchases made from Arizona suppliers and service providers:

	Dollar Value	Percent Purchased In AZ
Furniture		
Equipment		
Buildings		
Golf Course		
Other		

Current assessed value of total assets owned as of December 2014:

Land _____

Vehicles and equipment _____
Irrigation systems _____
Golf-owned buildings and installations _____
Total _____

Please provide a breakdown of federal, state, and local taxes paid in 2014:

Property tax _____
Sales tax _____
State corporate income tax _____
State payroll tax _____
All taxes paid to the federal government _____

Please estimate the monetary value of in-kind contributions to charities in 2014 (include only non-cash contributions such as free golf rounds, free lessons, etc.). _____

****THESE QUESTIONS ARE FOR THE GOLF COURSE SUPERINTENDENT / DIRECTOR OF AGRONOMY****

For golf facilities with multiple golf courses, please answer the following questions with regards to ALL golf courses at the golf facility

Did any golf course(s) at the golf facility undergo any major renovation projects in 2014? This question refers only to renovation of EXISTING courses, and does NOT include construction of NEW courses.

❍ Yes
❍ No

Please estimate the cost of any renovations undergone in 2014 for the golf course(s) and if an Arizona-based contractor was used for the project. Please do NOT include construction of NEW golf courses. For projects involving multiple contractors, the project should be considered Arizona-based if more than half of the project (in terms of dollar value) was performed by an Arizona-based contractor.

	Cost	AZ-Based Contractor Used?
Bunker renovation		❍
New greens		❍
New tees		❍
Cart paths		❍
Revegetation		❍
Re-sodding or resurfacing (beyond general maintenance)		❍
Irrigation system renovation		❍
Irrigation computer system upgrades		❍
Other (please specify)		❍

The following questions are regarding maintenance operations at the golf course(s)

Please estimate the total golf course maintenance expenses for 2014 for the golf course(s), excluding taxes: _____

Please estimate the breakdown of total expenses paid in 2014 for the golf course(s) as a dollar value or percentage, excluding taxes. Please complete only one column:

	Dollar Value ($)	Percent of Total (%)
Maintenance payroll (including all fringe benefits paid by the facility)		
Chemicals		
Irrigation water		
Plant material		
Seed		
Sand and soil		
Lease expenses (both operating and capital)		
Purchase of capital equipment (tractors, mowers, aerifiers, etc.)		
Utilities–electric		
Fuel–diesel & gasoline		
Other maintenance supplies and expenses		

Average number of full-time and part-time staff employed at your golf facility during 2014 for course maintenance:

Full-time employees _____
Part-time employees _____

The following section presents questions on water use and other management strategies

Area (in acres) used by the golf course(s) in 2014:

Total acres of golf facility (including clubhouse, golf shop, golf courses, restaurants, etc.) _____
Total acres of golf course(s) _____
Turfgrass acres maintained _____
Acres irrigated _____

Total amount of irrigation water used in 2014 (acre-feet per year). If you prefer not to respond, please mark with an 'X.' _____

Percent of total water used for irrigation, by source:

____ % Central Arizona Project (CAP)
____ % Surface water
____ % Groundwater
____ % Reclaimed water
____ % Other

Is your golf course facility in an Active Management Area (AMA)? (hover cursor over for definition)

- ○ Yes
- ○ No

Please indicate which irrigation method(s) your golf facility uses and the estimated percent of irrigated acreage under each method:

	Used by Facility?	Percent of Irrigated Acreage
Gravity	❑	
Sprinkler	❑	
Drip	❑	
Other (please specify)	❑	

Please indicate which, if any, of the following management strategies were used on your golf facility in 2014 (please select all that apply)

- ❑ Soil wetting agent
- ❑ Adjusted fertilization practices
- ❑ Eliminated irrigation in selected areas
- ❑ Reduced rough or fairway irrigation
- ❑ Aerified fairways and/or greens
- ❑ Hand watered greens and/or area in fairways
- ❑ Used in-ground moisture sensors and/or hand-held moisture meters
- ❑ Used automated weather stations
- ❑ Modified current irrigation system
- ❑ Installed or improved drainage systems on the golf course on fairways, greens, bunkers
- ❑ Water treatment or recirculation system for fertilizer or pesticide applications
- ❑ Raised mowing heights
- ❑ Walk mowed greens
- ❑ Scouted for insect pests, weeds, and diseases
- ❑ Modified irrigation scheduling to manage insects, weeds, or diseases

Please describe the facility's decision making process for selecting and investing in major efficiency upgrades, including information used, outside experts or resources consulted, or other internal or external factors considered.

_____

Has an irrigation system audit been performed in the past 5 years?

- ○ Yes
- ○ No

Were adjustments and corrections made to the irrigation system after the audit?

- ○ Yes
- ○ No

Estimated water savings per year (in acre-feet) as a result of adjustments and corrections from irrigation audit, if applicable: _____

The following questions are regarding turfgrass and landscape maintenance, and other management practices

How many, if any, acres of turfgrass have been removed in the past 5 years? _____

If turfgrass was removed, what vegetation or material was used to replace the turfgrass removed? (please select all that apply)

❑ Trees & shrubs ❑ Other (please specify): _____

❑ Native vegetation
❑ Mulch
❑ Not applicable

If your facility practices overseeding, please estimate the area (in acres) overseeded in 2014 and 2009:

Acres overseeded in 2014 _____
Acres overseeded in 2009 _____

Please indicate which, if any of the following, your golf facility practices:

❑ Overseeding rough areas
❑ Overseeding greens
❑ Overseeding fairways
❑ Overseed wall-to-wall
❑ Paint or color greens instead of overseeding

Does your golf facility have a partnership with, consult with, have a certification from, or is otherwise involved with any wildlife conservation organizations?

❑ Yes–Audubon Society
❑ Yes–Other (please specify): _____
❑ No

Have you ever attended a University of Arizona Cooperative Extension turfgrass or integrated pest management workshop, seminar, field day, etc.?

○ Yes
○ No
○ I prefer not to respond

Please indicate if your golf facility has adopted turfgrass management or integrated pest management practices as a result of attending and learning about topics at University of Arizona Cooperative Extension seminars, meetings, or events (please select all that apply)

❑ Overseeding practices
❑ Spring transition practices
❑ Turfgrass variety selection
❑ Weed control practices
❑ Insect pest management
❑ Disease management
❑ Irrigation management
❑ Other (please specify): _____

Appendix B: Survey Invitation Letter

DEPARTMENT OF AGRICULTURAL & RESOURCE ECONOMICS
Chávez Building
PO Box 210023
Tucson, AZ 85721-0023
(520) 621-6265
http://www.ag.arizona.edu/arec/

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

Dear General Manager,

April 20, 2016

In collaboration with Cactus & Pine GCSA, the University of Arizona Cooperative Extension is embarking on a research project to estimate the contribution of the golf industry to the state economy. A major component of this study involves collecting economic information directly from all golf course facilities within the state.

As one of over 300 golf facilities in Arizona, you are invited to participate in our survey.

The survey, available online for your convenience, presents a series of questions regarding golf facility operations in calendar year 2014. Questions are divided into 3 sections, with each section tailored to a different role at the golf facility. We ask that the following golf facility personnel participate in the survey: (1) **General Manager**, (2) **Lead Superintendent**, and (3) **Lead Golf Professional**. In some cases, an individual may serve multiple roles and the facility may include multiple courses. Please encourage the personnel listed above to complete all relevant sections and provide responses that pertain to the entire facility (multiple courses, if appropriate).

Your facility personnel's participation in this research is voluntary. All survey answers are anonymous and results will be reported in aggregate to maintain confidentiality.

To access the survey, please go to **www.extension.arizona.edu/golf** and enter the following information:

Username: azgolf
Password: survey123

If you and your personnel have already received an invitation via e-mail and all three roles have completed the survey, thank you for your participation! If not, please provide these instructions to the relevant personnel (listed above) to ensure that your facility is represented in all aspects. Your involvement is greatly appreciated and will help to provide an accurate estimate of the economic contribution of the golf industry in Arizona.

Sincerely,

Kai Umeda
Area Extension Agent, Turfgrass Science
kumeda@cals.arizona.edu

George Frisvold
Extension Economist
frisvold@ag.arizona.edu

Contribution of the Golf Industry to the Arizona Economy

Providing a much-needed update to the last available figures from 2004, this study will estimate the economic contribution of the golf industry, including the contribution from:

- Golf course facilities,
- Golf-related tourism, and
- Golf retail establishments.

In addition to estimating the sales and jobs directly supported by the Arizona golf industry, the study will estimate the economic activity that is indirectly supported by the industry. This includes the ripple of economic activity that is stimulated in non-golf industries.

Finally, this study will collect more detailed information on water use and conservation practices at Arizona golf course facilities.

THANK YOU IN ADVANCE FOR YOUR PARTICIPATION!

Should you have any questions or experience difficulty accessing the survey, please contact us at eia-team@cals.arizona.edu

Appendix C: Scaling and Expansion Method

According to basic characteristics of responding facilities, the total survey response by respondent role mirrors the overall distribution of golf facilities in Arizona. Individual question response varied, however, and for that reason it was necessary to use a method to adjust for bias for each question's response. To correct for bias in survey responses, the data collected for each question with a numeric response was segmented by facility size as measured by number of holes. For each question, an average and number (n) of observations was calculated for each facility size. The averages were then scaled according to the table at right as if they were an 18-hole facility, multiplying by the scaling factor.

Each scaled average was multiplied by the number of observations for each size category, and then summed and divided by the total number of observations to get a weighted 18-hole average for the entire response. This weighted 18-hole average was then scaled back up according to the number of facilities by size in the full golf facility database to obtain a statewide estimate (table below right).

This scaling method accounts for the varying response rate by facility size for each question, and captures variation in per-hole values by using weighted averages.

Scaling Down Factor by Number of Holes

Holes	Scaling Down Factor
9	2.00
18	1.00
27	0.67
36	0.50
45	0.40
54	0.33
72	0.25
81	0.22
99	0.18
108	0.17
117	0.15
126	0.14
135	0.13

Scaling Up Factor by Number of Holes

Holes	Scaling Up Factor	Facilities	Total Scaling Factor
9	0.5	37	18.5
18	1.0	211	211
27	1.5	22	33
36	2.0	39	78
45	2.5	2	5
54	3.0	1	3
72	4.0	0	0
81	4.5	0	0
99	5.5	0	0
108	6.0	1	6
117	6.5	0	0
126	7.0	0	0
135	7.5	0	0
Total		**313**	**354.5**

Appendix D: Economic Contribution Analysis Methods

The economic contribution of the golf industry was estimated using the 2014 IMPLAN Version 3.1 input-output model. The IMPLAN model captures the linkages between economic sectors in a particular region and is used to understand how specific industries or economic events affect the regional economy overall. The data used in this model represent Arizona's state economy in 2014.

The economic contribution of golf facility operations in 2014 was modeled using a technique known as analysis-by-parts, in which spending on wages and salaries is modeled separately from expenditures on goods and services. Furthermore, profits were modeled as proprietor income, of which 50% was assumed to be retained in-state. Local purchase percentages were set to SAM values. The breakdown and spending pattern can be found in Appendix E. The tax contribution of golf facility operations was modeled using an industry change for industry '496 Other amusement and recreation,' the IMPLAN industry which contains golf courses. Proprietor income, employee compensation, and employment were customized to match statewide estimates derived from survey results.

The economic impact of golf tourism was modeled using a series of industry changes. Tourist spending attributable to golf, estimated in previous sections, was used model the impacts to industries (Appendix E). Retail industries were margined, meaning that retail margins were retained in-state, while the cost of merchandise was considered as a leakage from the state economy. Direct effects were measured as gross sales for all retail industries. Local purchase percentages were set to 100% as the direct spending is all assumed to occur in-state.

The economic contribution of golf-related businesses was also modeled as a series of industry changes (Appendix E). Again, retail industries were margined and direct effects of retail industries were measured as gross sales. Local purchase percentages were set to 100% as all direct spending is assumed to occur in-state.

Appendix E: IMPLAN Industry Assignments for Spending Patterns

Golf Facility Operations

General Breakdown

Item	Amount	Modeled As:
Payroll	$355,824,799	Labor Income Change (Employee Compensation)
Operating Expenses	$523,944,430	Industry Spending Pattern
Profits	$267,597,566	Labor Income Change (Proprietor Income, 50% Leakage)

Industry Spending Pattern (Operating Expenses)

IMPLAN Industry	% of Spending
3010 All other crops	2.7091
3031 Sand and gravel	0.9030
3049 Electricity transmission and distribution	7.3169
3050 Natural gas distribution	1.8292
3051 Water, sewage and other systems	9.1461
3169 Nitrogenous fertilizer	1.8061
3170 Phosphatic fertilizer	1.8061
3395 Wholesale trade distribution services	23.9514
3402 Retail services-Gasoline stores	2.7091
3434 Nondepository credit intermediation and related activities	3.0933
3437 Insurance	2.4403
3440 Real estate buying and selling, leasing, managing, and related services	5.1653
3457 Advertising, public relations, and related services	2.6157
3462 Office administrative services	15.8084
3469 Landscape and horticultural services	8.1274
3496 Other amusement and recreation	10.3443
3514 Grantmaking, giving, and social advocacy services	0.2284

Golf Tourism

Expenditure	IMPLAN Industry	Amount
Lodging	499 Hotels and motels, including casino hotels	$198,894,182
Car Rental	442 Automotive equipment rental and leasing	$65,711,964
Food / Dining	501 Full-service restaurants	$82,365,863
Entertainment	496 Other amusement and recreation industries	$45,871,833
	494 Amusement parks and arcades	$45,871,833
Local Transportation	412 Transit and ground passenger transportation	$40,805,608
Shopping / Retail	403 Retail–Clothing and clothing accessories stores	$57,402,273
	406 Retail–Miscellaneous store retailers	$57,402,273
Groceries	400 Retail–Food and beverage stores	$3,974,413

Golf-Related Businesses

Industry	IMPLAN Industry	Amount
Golf Vacation Packages	466 Travel arrangement and reservation services	$4,668,000
Golf Cars & Carts	396 Retail–Motor vehicle and parts dealers	$161,036,000
Golf Equipment & Supplies—Retail	404 Retail–Sporting goods, hobby, musical instrument and book stores	$94,134,000
Golf Equipment—Repairing & Refinishing	508 Personal and household goods repair and maintenance	$679,000
Golf Practice Ranges	496 Other amusement and recreation industries	$3,426,000
Golf Instruction	474 Other educational services	$6,217,000